CLIFF-NESTING RAZORBILLS

Razorbills breed in their thousands on our precipitous western and northern cliffs but spend the rest of the year over the sea. They are poor flyers, their wings actually being used as much for swimming as flying.

The razorbill is notable for its distinctive stance, elongated silhouette and striking black and white summer plumage. The stance of this bird on its breeding cliffs is usually upright, whereas on the water it appears low-lying and short-necked and about the size of a teal, but with the rather long, pointed tail usually held up at an angle.

Summer and winter appearance In summer the razorbill's underparts are pure white, while the tail, back, wings, neck and head are jet black, relieved only by a white vertical mark near the tip of the black beak, by a white line of 'furry' feathers stretching from the 'bridge of the nose' to the eye, and by a bold white wing bar. In flight this wing bar forms a conspicuous trailing edge on the inner half of the wing, visible both from above and below, and more striking than the wing bar of the otherwise confusingly similar guillemot. (At close range, confusion between the two is less likely since the slender, more dagger-shaped beak of the guillemot can be seen contrasting with the deeper, stouter beak of the razorbill. The guillemot is also chocolate-brown rather than black.)

The purpose of the white lines on the bill and head is not properly understood. It may be that they are simply plumage features that play a part in the razorbill's courtship: certainly display involves much preening and nibbling of the partner's head and neck. An alternative proposal – as yet untested – suggests that the marks may be of use when the razorbill is fishing under water, acting almost as the sights on a rifle.

In winter, when some of our razorbills remain well offshore in British waters, confusion with guillemots is even more likely.

Above: A razorbill in the typical upright stance. The white wing bar and beak stripe are particularly conspicuous. The beak is smaller in winter, the summer beak having been shed at the autumn moult.

Below: A group of razorbills – the wings are noticeably flipper-like in appearance.

Both birds moult to a nondescript grey above, with smudgy margins, while the dark head is replaced by a pale greyish neck and face. As many are seen at long range, identification is often uncertain and only birds close enough to see the longer tail of the razorbill, or its square-ended beak, can be positively named.

Coastal distribution The results of ringing studies of British and Irish razorbills show that, in general, they travel further than guillemots, many reaching Mediterranean waters by mid-winter. In common with some other birds (gannets and gulls for example) razorbills, as they become older, tend to travel shorter distances during the winter, rarely moving further than the North Sea or the Bay of Biscay. Ringing recoveries also show that man plays a large part in causing the death of these birds: about half of those found dead are reported killed either by oiling, by being shot by Continental sportsmen, or by being drowned in fishing nets.

As much as 70% of the world razorbill population breed in Britain and Ireland. What makes our islands so special in this respect? Compared with much of Europe, our western and northern coasts, and the off-shore islands, are girt with precipitous cliffs. They form natural reserves, protected by treacherous and often rough seas. The rock of these cliffs, too, is often of just the type needed by the razorbills, cracking and fracturing to provide appropriate ledges and crevices. Some razorbills nest on open ledges, but many prefer cavities in the cliff face or seek similar shelter from such predators as the great black-backed gull deep beneath the rocks in the screes at the top or foot of the cliffs.

Most razorbill colonies are relatively small and interspersed with those of other auks; few colonies reach 10,000 pairs and only one, on Horn Head in County Donegal, is of any great size, perhaps exceeding 45,000 pairs. *Operation Seafarer*, a survey of our seabirds conducted in 1969-70, suggested an estimated 144,000 pairs as our grand total, and sample censuses since then would indicate little change, or perhaps a slight increase, in the last decade.

Courtship and breeding Razorbills may visit their breeding cliffs in fine weather almost any time after the New Year, but attendance becomes much more regular from March onwards. On the cliffs, pairs indulge in mutual neck-nibbling, but the sky is full of pairs involved in the 'butterfly' display. In this, the wing-beats are slowed right down and are exaggeratedly deep–hence the name.

The single massive egg is laid in mid-May and incubated in turn by both parents. As might be expected from the protected nature of the nest site, the razorbill egg is of normal chicken-like shape, not pointed and top-shaped like that of the exposed ledge-nesting guillemot. However, the spots and squiggles of dark markings, and the background colour

Above: A staggering 70% of the world population of razorbills breed in Britain and Ireland, finding security on the inaccessible cliffs of our coasts.

Right: Only one large egg is laid each year by the razorbill; it is incubated by both parents.

Below: At the age of two or three weeks the razorbill chick must make its way down the cliffs to the sea, where it is safer from the predations of gulls.

of the shell, are just as varied as those on the guillemot egg, and presumably help the returning bird to identify its own egg among many others. During the nesting season the pair communicate with each other and with their neighbours using a variety of sepulchral, grumbling, low-pitched groans, but at other times they are totally silent.

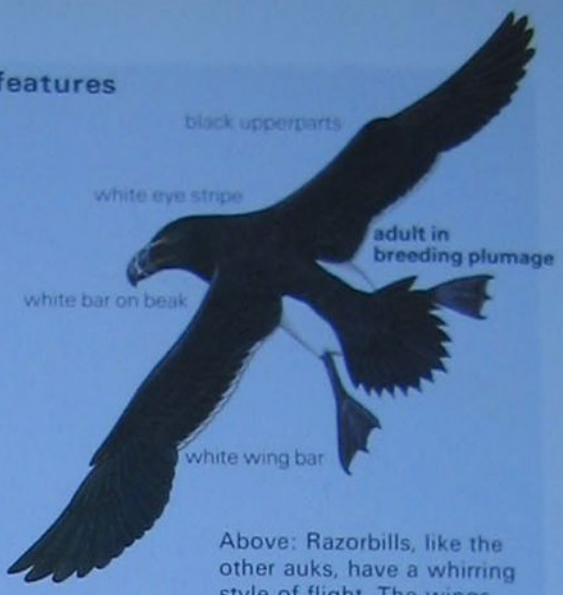
The egg hatches about a month later, in mid-June, and is then fed by both parents. Like puffins, razorbills return to the nest carrying a beakful of several small fishes held crosswise. The approach to the nest is often difficult in the winds blowing about the cliff face. Razorbills, being heavy-bodied, with short, stiff wings, are not very manoeuvrable and may have to make several approaches before achieving a good landing.

Taking to the sea The razorbill chick remains on the nesting cliffs for only two or three weeks. Then, usually under cover of darkness to protect it from gull predation, it jumps from the cliff down into the sea. At this stage it is only half-grown, its wings little more than stubs and certainly incapable of sustaining flight for any length of time. Nonetheless, most chicks seem to survive perfectly well, protected by their down and fat from injury on the rocks on the way down. The chick then sets off for the open sea, accompanied by at least one of its parents. Whatever the apparent hazards, it would seem that this is less risky than staying on the cliffs to be persecuted by the gulls. While they are still at sea caring for the flightless chick, the adults moult all their flight feathers at once, thus themselves becoming flightless.

Diving and swimming The chicks can swim and dive well by the time they take to the sea, and beneath the water the birds are fast and expert swimmers, using both feet and wings for propulsion and steering.

Razorbill recognition features

The juvenile razorbill (below) looks much like the adult in shape, but has a shorter, blunter bill with no white stripe. In colour it resembles the adult in winter plumage, having greyish-white cheeks and throat patches. Male and female razorbills have similar plumage, both in summer and in winter.



Above: Razorbills, like the other auks, have a whirring style of flight. The wings are used as much to propel the bird through the water as the air, while the large webbed feet (which act rather like the flaps on aircraft wings) are often used to steady and control the bird while landing—they are held in a 'straddled' position away from the body. The narrow, stiff wings and heavy body combine to make the razorbill somewhat clumsy in the air.

The body skeleton is better suited to life beneath the water than to flight, being a robust 'box girder' structure. A stout, inflexible backbone is joined to a strong breastbone by thick ribs, each with a backward-pointing projection overlapping the rib behind for additional strength. Within this rigid box the body organs are protected from the pressure of water during dives often many metres below the surface. The razorbill's prey includes sand eels, small sprats and the fry of a wide range of fishes and also some shellfishes and shrimps.

Above: Four members of the auk family occur in Britain and Ireland: the puffin, razorbill, guillemot and black guillemot. They are all black and white birds characterised by an upright stance and the fact that they are expert divers and underwater swimmers. (Another member of the family, the great auk, became extinct in 1844 because of the depredations of egg collectors.) The puffin is the smallest of the four at 30cm (12in) long; the next smallest is the black guillemot (34cm/13½in), while the razorbill and guillemot are much the same size (41cm/16in long).

Razorbill (*Alca torda*). Resident seabird in British and Irish waters, breeding on precipitous cliffs on western and northern coasts and offshore islands; sea-going for rest of year. Length 41cm (16in).

Left: On the water razorbills appear low-lying and rather short-necked.

RABBITS: PAST, PRESENT AND FUTURE

Rabbits are plainly here to stay, but attitudes to them are ambivalent: they are cuddly pets, attractive fauna, sources of sport and meat or serious pests, depending on your viewpoint. They have recolonized most of their former range since myxomatosis, but still have far to go numerically.

Above: Rabbits can influence the appearance of the countryside by feeding on crops, many wild grasses and other herbage, maintaining short grassy turf, with its associated flora, preventing scrub regeneration, and undermining river and sea defences.

Below: A rabbit lying up in long grass in a typical form.

Wild rabbits, a familiar and attractive sight in our countryside, are a most successful species, quite capable of devastating our food and timber crops.

European rabbits, from which all our domestic rabbit breeds originate, are a very adaptable species in the wild, living in a wide range of conditions in various parts of the world. They have demonstrated their success despite adversity by surviving and recovering from the deadly impact of myxomatosis, a disease which almost eliminated them from the British Isles. They are social animals, often found in large colonies centred upon complex burrow systems, but they can also live above ground in surface vegetation.

Rabbit history Rabbits are not native here but were introduced in the early 12th century,

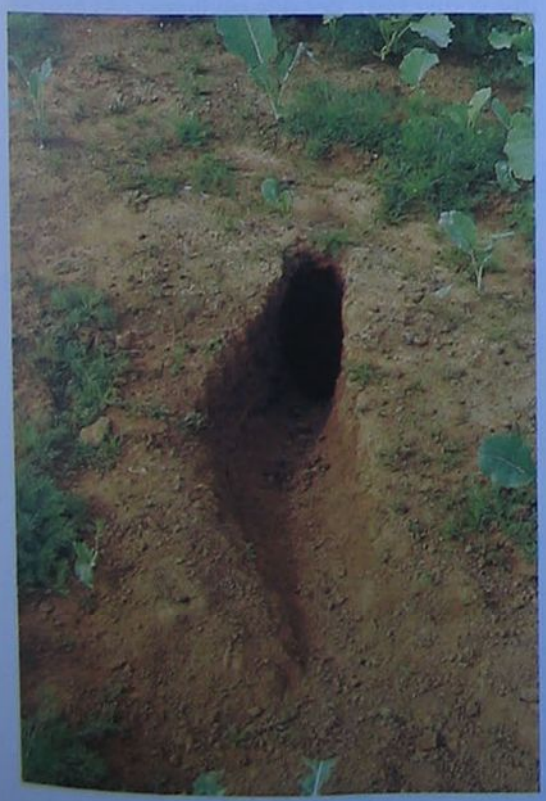
when they were kept in large enclosures or warrens for their flesh and fur. By late medieval times many hundreds of rabbit warrens were established throughout the country, but from the 18th century onwards they were gradually disbanded and very few commercial warrens survived in use to this century. Warrens were by no means secure, however, and rabbits escaped periodically, causing damage to cereal crops and pastures from the 14th century onwards. It was not until the 18th century Agricultural Revolution that widespread changes in suitable cover (planting of hedges and woodlands), food supply (abundant overwinter fodder crops), sport (deliberate spreading of rabbits) and natural predators (intensive control to preserve gamebirds) favoured the long-term survival of escaped 'feral' rabbits.

The newly wild rabbits flourished and by 1850 they were a major pest, although only landowners could kill them legally. This problem for tenant farmers was redressed by the 1880 Ground Game Act, so that in the early 20th century men earned their livings by gin trapping and snaring rabbits.

By about 1950 all types of rabbit damage were estimated to cost the country £50 million a year in reduced yields, but with the arrival of myxomatosis in 1953 rabbit numbers were reduced within just two years to under one per cent of their previous levels. Since then recovery has been slow but continuous, and rabbits were re-established in some parts of the British Isles by the 1960s; but even now numbers have only reached an estimated 20% of their pre-myxomatosis abundance nationwide.

Rabbit habitat Rabbits originate from Mediterranean France, Iberia and north-west Africa where the habitats are now dry and nutritionally poor in summer. Where they have been introduced by man to other parts of Europe the limits to their distribution and altitudinal range are set by the persistence and depth of winter snows. Rabbits occur throughout mainland Britain today up to around 600m (2000ft), and on most large and small offshore islands. Our temperate conditions, particularly on islands, are favourable to rabbits and they have adapted to a wide variety of habitats here.

The presence of suitable feeding areas and safe cover nearby largely determines the distribution of rabbits, while the quality of the habitat influences their numbers. Patches of close-cropped cereals or grass, such as permanent pastures, chalk downland, grassy heaths and maritime grassland, are all favourable feeding sites. By persistent grazing rabbits actually create these preferred short-turf conditions, which are important for the



Above: A rabbit at its burrow in woodland, and (below) two contrasting habitats: a field burrow in sandy soil with a kale crop in Sussex (left) and a raised burrow in an earthstone wall on Skokholm Island, Wales (right). The suitability of soils—how easy burrows are to dig and maintain and whether they are liable to waterlogging—is important, with the highest rabbit numbers on light, sandy soils. Seasonal variations in the quality of food supplies and cover as well as such extremes of climate as prolonged snow, drought or excessive rain all affect breeding success and survival in any particular locality.

survival of young rabbits as they are easily wetted in long, damp grass and rapidly die from exposure. Secure cover includes underground burrows which may be in undisturbed open ground or raised banks, under dense vegetation, rocks or walls. Alternatively, above ground cover, such as thick undergrowth in hedgerows, scrub or woodlots, gaps in drystone walls, rock fissures or between boulders, is used.

Prolific breeders Rabbit populations are composed of roughly equal numbers of males (bucks) and females (does), although often there is a slight excess of does. There is, theoretically, a huge potential for increase, with up to 40 live young (kits) produced every year by each doe under ideal conditions, leading to a twenty-fold increase in the breeding stock every year; but these high production and survival levels are only rarely achieved.

The main breeding season spans 18-24 weeks between late January/February and July/August, but a few rabbits are pregnant in other months in most years. The gestation period is about four weeks, followed by three and a half weeks of suckling but, as mating occurs within two days of birth, does are both suckling and pregnant for most of the season. They produce four to six litters in this time, averaging five (but varying between one and ten) kits per litter.

Above: A very severely grazed heather bush. Rabbit grazing can convert such heathland to a grassy heath.

Left: Damage to a pine tree. Barking occurs in winter, especially when snow covers other foods. Damage often appears to be higher than rabbits could be expected to reach—this is because the snow has given them extra height.

Below: A rabbit scent-marking. Rabbits are social animals and communicate mainly by marking objects with their scent glands.

Weather conditions and rabbit abundance influence production levels by affecting the length of the season and the success of pregnancies. Many of the litters conceived may be terminated during pregnancy, but the does mate again within two days of losing their young, once more with variable success. In very high density rabbit populations such litter losses are frequent and the total season is reduced to under 15 weeks, resulting in about 10 live young born per doe each year. In contrast such litter losses are minimal in very low density populations and the total season is extended to 28 weeks, with over 30 live young born per doe each year. At present an average of 20-22 young per doe is born each breeding season.

Although born into snug underground nests, the kits are extremely vulnerable to predation or flooding, so even fewer survive the three weeks before emergence. The high mortality continues above ground and only about 10% of the original young born live to see their first winter, though the odd resourceful rabbit may, with luck, survive for five or six years.

Today's populations Because of this rapid turnover the overwinter population of rabbits (next season's breeding stock) contains on average one yearling for each older rabbit, with very few rabbits over three years old. At present winter numbers are surprisingly stable from year to year in many areas, with just a slight upward trend apparent. Elsewhere populations are unstable, with small colonies declining to extinction while new ones pop up in other places.

Population size varies seasonally as the annual cycle of births and deaths proceeds, but summer peak levels exceeding five times the winter trough levels are quite exceptional.

Before myxomatosis rabbit densities reached 10-50 per hectare (5-20 per acre) seasonally, especially in western England and Wales, and even higher on islands. Only recently have rabbit numbers approached these levels in localised areas, mainly in eastern England. These considerable variations are caused by several interacting factors in any locality: extremes of climate – which can lead to starvation of flooded nests – and the suitability of the soil and the surrounding habitat.

Many diseases and parasites afflict rabbits, but myxomatosis remains the most important. This virus disease, transmitted by blood-sucking insects, still kills many rabbits, especially the young, during autumn and early winter, and is present more or less continually in most populations.

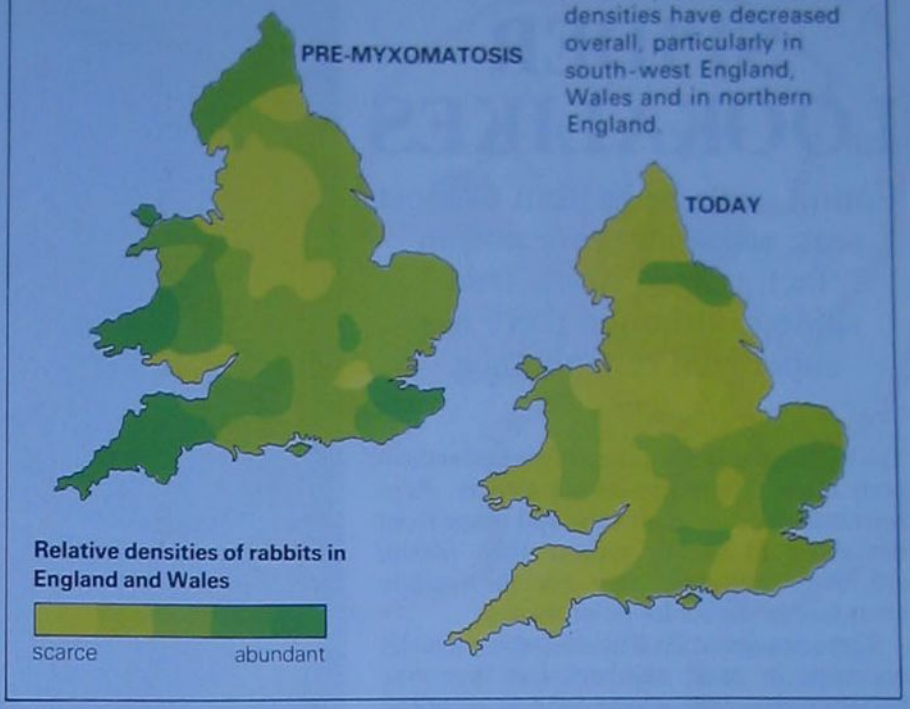
Since its introduction here both virus and host have changed in a complex manner. The original extremely powerful virus has been replaced by a range of virus strains, varying considerably in their potency. Rabbits which recover from less severe infestations acquire substantial protection from further attacks, and immune does can give their offspring temporary protection while they are still suckling. More recently genetic resistance to myxomatosis has developed in some rabbits – an inherited ability to survive infection by the disease. Despite all these changes, which continue to develop, myxomatosis still plays a significant role. Coccidiosis, caused by protozoan parasites, can also produce high mortality of young rabbits where densities are high.

Predation can exert an effect on rabbit numbers too, particularly on the survival of young rabbits in summer. Important predators of nestling, young and adult rabbits include fox, feral cat, badger, polecat, stoat, weasel, buzzard and other raptors. Man also influences rabbit numbers, both directly and indirectly, through killing for sport or pest control, road or farm machinery deaths, control of predators, changes in cropping patterns, use of herbicides and fertilizers, removal of hedgerows and scrub and felling of woodland.

Rabbits are most serious pests to farmers. They feed on many agricultural crops, destroying areas or reducing yields of cereals, pasture, hay, silage, roots and brassicas. Damage to forestry and orchards includes the removal of shoots and bark from young trees, and bark stripping from older tree trunks. Salad crops, vegetables and flowers are eaten in market and private gardens, and even from glass houses.

The respite given to farmers by myxomatosis has amply demonstrated that rabbit populations need management, and under the 1954 Pests Act all occupiers are legally obliged to take reasonable steps by, for example, gassing or fencing to destroy wild rabbits on their land or prevent them from causing damage. Even so, they are still one of the most abundant mammals to be found throughout the British countryside.

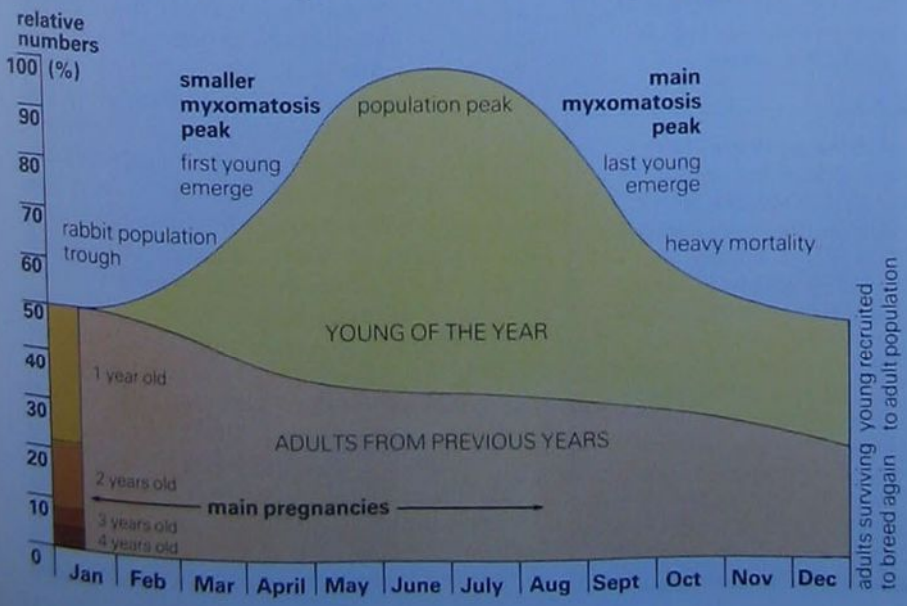
Rabbit populations



Research has shown that since myxomatosis rabbit densities have decreased overall, particularly in south-west England, Wales and in northern England.

Below: The diagram shows how a rabbit population fluctuates tremendously within a year, with a rapid turnover of generations. The main breeding season spans 18-24 weeks between late January/February and July/August, reaching a peak in April and May. Four to six litters a year are quite common, with an average of five kits to a litter. Females can breed at 3½ months old. Myxomatosis (below right) is present more or less continuously, although it is most obvious in early autumn and also in the spring month.

The annual cycle of a rabbit population



MARINE SPIDER LOOKALIKES

Found near the bottom of most seas, sea spiders are not, in fact, related to the true spiders, although there is a superficial resemblance.

Above: Male *Nymphon gracile* carrying eggs on his ovigerous legs. This species is one of the more spider-like members of the class, and bears a pair of pincer-like chelifores on either side of the proboscis. Alongside the chelifores are a pair of five-jointed palps. *Nymphon gracile* is found on the middle and lower shores, as well as in shallow water.

The Pycnogonida are a class of marine arthropods often referred to as sea spiders. Representatives occur in all seas, and range from the shore to depths greater than 6000m (19,700ft), although they are particularly abundant in the colder polar waters.

There are about 20 British species, usually occurring in small numbers, but they may be more abundant where food is plentiful. Their bodies are typically only about one millimetre long, but some of the deep water forms reach 5cm (2in) in length and have a leg-span of 30cm (about 12in). In many species the body is narrow and is divided into distinct segments. The body is considerably reduced compared with that of most other arthropods, and is for the most part derived from the fused head and thorax. The part usually referred to as the abdomen is a single-segmented protuberance, with the anus at its tip. In most species there are four pairs of legs, but in some there are five or even six pairs.

Multi-purpose proboscis The mouth is situated at the end of a snout-like proboscis—an unusual feature in arthropods. The proboscis varies in length according to the species, and in some may account for half the length of the body. The front end of the body has varying combinations of a pair of palps and a pair of structures known as chelifores. In some species, for instance *Pycnogonum littorale*, neither is present, while in *Endeis spinosa* chelifores alone are present, and then only in the immature stages. *Nymphon gracile*, a common species in British waters, has both palps and chelifores. The palps bear numerous hair-like structures called setae, and one of their functions is presumably sensory. In many species the chelifores are equipped with a number of teeth, enabling food to be held against the mouth during feeding.

On the upper surface near the front end of the body is a projection, known as a tubercle, which bears the eyes. The immature stages have one pair of eyes but, during development, two more form. One pair is directed forwards, and the other pair is directed backwards. Although each eye has a lens and pigment coating, and is sensitive to light, they do not form an image. In some deep water species the pigment layer has been lost.

Internal anatomy Internally, sea spiders are fairly simple. No excretory or respiratory systems have been observed, and it must be assumed that gaseous exchange takes place over the body surface. The circulatory system is also simple. The gut is a simple tube passing from the mouth to the anus, with a pumping mechanism in the proboscis. Branches of the gut pass down all the limbs.

The food taken varies with the time of year,

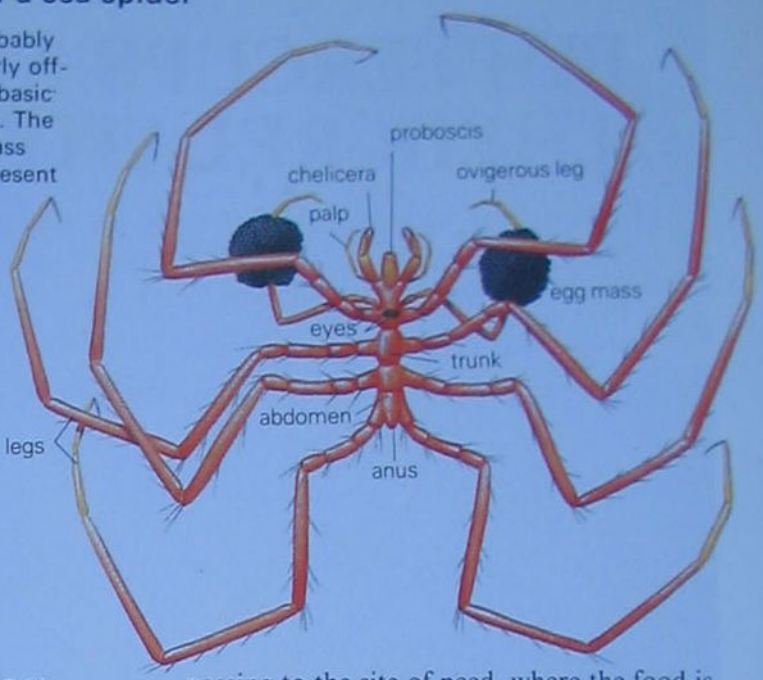
'Wait-and-feed'

Achelia echinata (left), a common sea spider in British waters, is shown here crawling over a bryozoan colony. Feeding consists of the sea spider waiting poised above the colony until some unwary soft-bodied polyps emerge from their cases. It usually takes several hopeful stabs at the polyps with the sea spider's proboscis before a meal is secured and devoured.

as the animal grows, and from species to species. The most frequent diet consists of hydroids and bryozoans, or the organisms and debris that grow and accumulate on them. This food source, and hence sea spiders themselves, are more common on firmer bottoms such as those provided by rocks. During feeding, the mouth of the sea spider is placed against the food, enzymes pass from the gut on to it, and the resulting partly digested material is sucked in by the proboscis. An unusual method of digestion has been observed, in which food absorbed by cells from one part of the gut wall may be transported to another part of the body by those cells detaching from the gut wall and passing to the site of need, where the food is absorbed by other cells. With the food exhausted, the floating cells are eliminated through the anus.

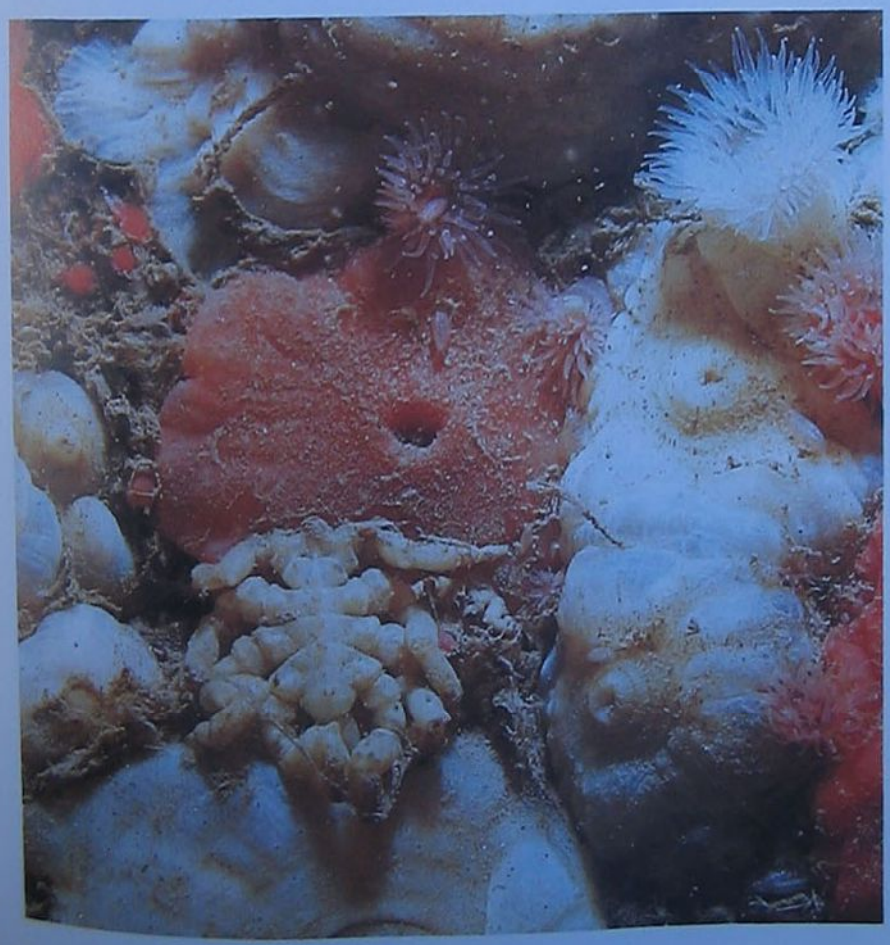
Anatomy of a sea spider

Sea spiders probably represent an early offshoot from the basic arthropod stock. The true spiders (class Arachnida) represent another line of development.



Left: Plummeting or 'parachuting' down in the water is a useful rapid escape mechanism for an otherwise slow mover.

Below: The original 'Michelin' man? *Pycnogonum littorale* is about 2cm (1in) long. The body bears no palps or chelifores. This sea spider, seen here on sea anemones, is found under stones on the lower shore.



Slow progress Most species of sea spider live on the sea-bed throughout their lives, and can only crawl slowly over the substratum. A few species, such as *Nymphon gracile* which has a thin, delicate body, can lift themselves from the bottom by 'treading water'. If they then assume a slightly forward and downward-facing posture, some degree of forward swimming movement is possible. However, water currents usually have more effect on movement. These limited powers of locomotion mean that there is seldom widespread dispersal of individuals.

Breeding and life-cycle The sexes are usually separate. The U-shaped reproductive system lies within the trunk of the body, with branches down the legs. In the females the eggs usually develop in the legs. The genital openings are on the leg segments referred to as the second coxae. *Nymphon gracile* has eight genital openings, *Achelia echinata* has four, and *Pycnogonum littorale* has two. The mature eggs are released and then collected by the male on appendages on the underside of his body referred to as ovigerous (egg-bearing) legs. These are sometimes also present in the female.

In addition to collecting the eggs, ovigerous legs may be used to clean the surface of the body. Before collecting the eggs the male fertilises them and sometimes cements them into a ball. They then hatch and the larvae, referred to as protonymphon larvae, are carried by the male for some time. When sufficiently mature they are released on to a suitable habitat, where they develop first two pairs of legs, then three pairs and eventually four pairs. As in many other arthropods, there is a succession of moults which, in sea spiders, continues even after sexual maturity.

BUTTERCUPS AND THEIR RELATIVES

The familiar buttercup of meadows and grassland gives its name to one of the most primitive families of flowering plants, a group that includes such attractive species as pasque flower, marsh marigold and pheasant's eye.

Above: In the buttercup family only one genus, *Ranunculus*, is represented in Britain by more than a few species. There are over 20, including the familiar buttercups—such as meadow buttercup shown here—water crowfoots and spearworts.

Left: Among native members of the buttercup family, pasque flower (shown here) and wood anemone are unique in having their stem leaves borne in a whorl just below their flowers.

The buttercup family—scientifically known as Ranunculaceae—is a large and diverse family whose members display considerable variations in their leaves and flowers. Yet, despite these variations, the flowers have essentially a very simple structure. The stamens and carpels (which are the male and female parts) and the perianth (the petals and sepals) are arranged spirally and regularly around the centre of the flower and they are all free from one another.

These characteristics are considered by botanists to indicate a primitive flower. More advanced flowers tend to have their parts fused together—such as the carpels joining to form an ovary—and in many cases they have lost the radial symmetry possessed by buttercups and other primitive flowers. Flowers of the much more advanced pea family, for example, are symmetrical only about a single plane passing down through the centre of the flower.

British members World wide, there are about 50 genera in the buttercup family. Of these, 12 are native to the British Isles and a further four genera are widely naturalised or occur as weeds of cornfields. Among our native genera only one, *Ranunculus*, has a large number of British species—at least 20. Most of the others are represented by a single native species.

The buttercup family is divided into two groups, called subfamilies, based on the number of ovules in each carpel. One group, the Helleboroideae, have carpels that contain more than one ovule, which means that the ripe fruits contain more than one seed. This group includes monk's hood (genus *Aconitum*), columbine (*Aquilegia*), marsh marigold (*Caltha*), globeflower (*Trollius*), the hellebores (*Helleborus*) and baneberry (*Actaea*). The six remaining British genera are grouped into the other subfamily, the Ranunculoideae. They differ from the first group in having carpels containing a single ovule so that the ripe fruits have a single seed. In this subfamily are the buttercups, spearworts and crowfoots (*Ranunculus*), meadow-rues (*Thalictrum*), wood anemone (*Anemone*), pasque flower (*Pulsatilla*), traveller's joy or old man's beard (*Clematis*) and mousetail (*Myosurus*).

Annuals and perennials Many members of the buttercup family are perennials, overwintering by means of rhizomes, for example marsh marigold and species of *Ranunculus*. Others have erect, non-rhizomatous stems and may be either perennial, such as pasque flower, or annual, as are mousetail and larkspur. Some species of *Ranunculus*, as well as producing rhizomes, also produce stolons—short-lived creeping stems which run above or below ground. A familiar example is the creeping buttercup (*Ranunculus repens*).

The leaves of most plants in the buttercup family are of two types: those arising from the base of the plant and those arising from the upright flowering stem. The basal leaves

can have a wide variety of shapes, from lanceolate (spear-shaped) to lobed or very deeply and finely dissected. In a few species, such as marsh marigold and wood anemone, the stem leaves are similar to the basal leaves but in most cases are noticeably different, a phenomenon known as heterophylly.

An extreme example of heterophylly occurs in the water crowfoots. These plants frequently bear floating and submerged leaves, the former being lobed and the latter being very finely dissected.

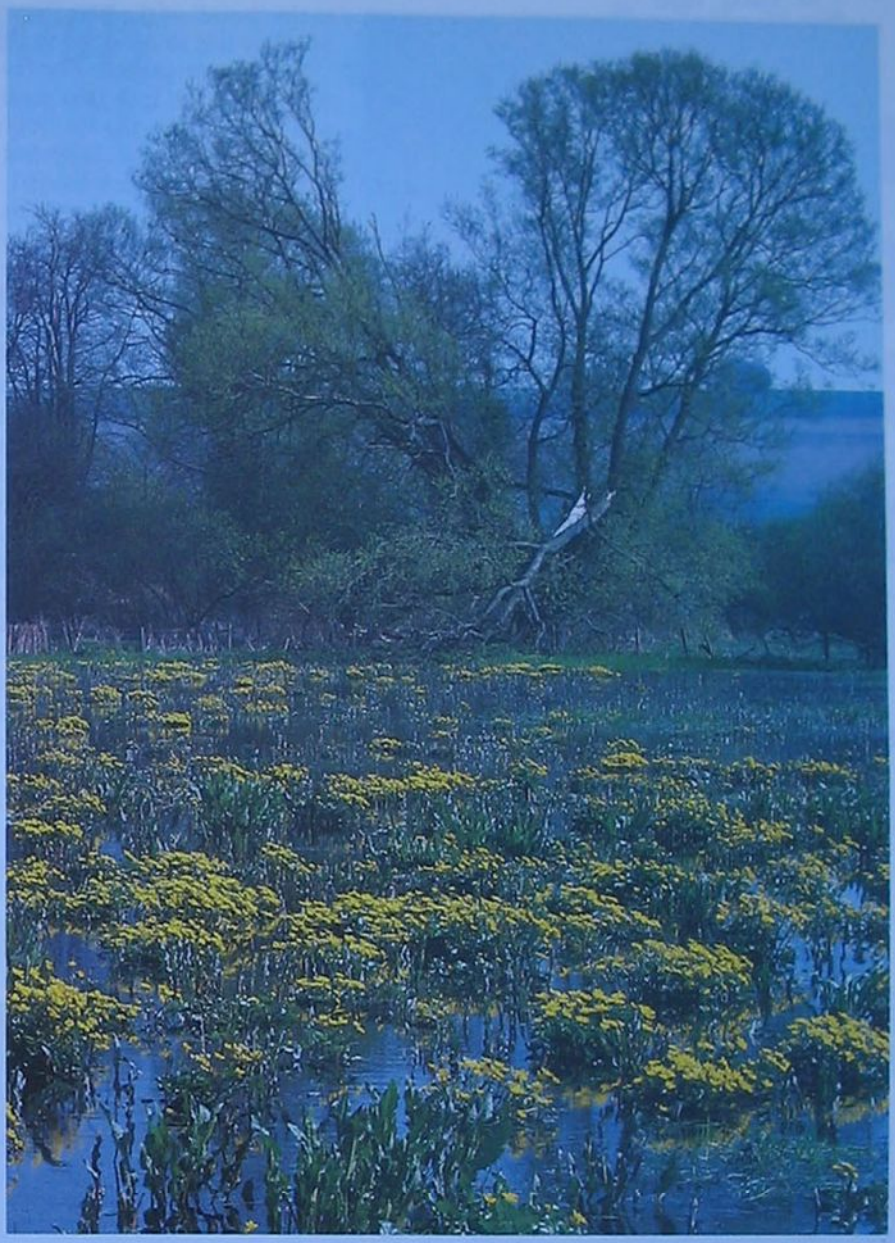
Woody and herbaceous All plants in the Ranunculaceae are herbaceous with one exception–traveller's joy, which is a woody climbing shrub. Yet curiously, the stems of *Ranunculus* species are the complete opposite of the woody stems of traveller's joy for, unlike most plants–whether herbaceous or woody–they lack the cells capable of producing the wood-forming tissues. This, and other features of *Ranunculus* stems, are more typical of monocotyledons than dicotyledons, to which the buttercup family belongs.

In general, woody plants are thought to be more primitive than herbaceous ones, but not in the case of traveller's joy. Features in this plant's wood suggest that it was once herbaceous, and only later in its evolution did it become woody. Thus the buttercup family is not as primitive as some woody flowering plant families, such as the magnolia family, which is the most primitive of all the flowering plant families.

Flower structure The flowers of the buttercup family are borne on erect stems and may be solitary or part of an inflorescence. In colour, many have the typical yellow of a buttercup, but others are frequently white while a few are blue, green or red.

Among the species found in Britain, only in pheasant's eye and members of *Ranunculus* does the perianth consist of both petals and sepals. In other genera the perianth consists solely of petals, which vary in number between four in traveller's joy and 15 in globeflower.

Although the flowers of many members of the buttercup family have a very simple structure, those of others show some interesting modifications.



Above: Most of the common Ranunculaceae are found in woodland, hedgerows, waste land or meadow land. Exceptions include marsh marigolds, shown here, and some species of *Ranunculus*, such as spearworts, which grow in marshes, fens and stream sides.

Left: Marsh marigold belongs to the subfamily Helleboroideae, whose fruits mature into follicles–dry, many-seeded fruits that split open along one margin to release their seeds while still on the plant. The other subfamily, Ranunculoideae, has fruits that mature into achenes–dry, single-seeded fruits that are shed from the plant without splitting open to release their seed.

Most species in the family are insect-pollinated but the flowers of a few species have become modified for wind pollination. Examples include some species of meadow-rue, whose flowers have a reduced perianth and elongated filaments to ensure free dispersal of the pollen.

Wind pollination, however, wastes a great deal of pollen, as do those insect-pollinated flowers in which the pollen acts partly as a food to attract insects. Other plants in the Ranunculaceae have developed the much more efficient process of producing nectar to attract potential pollinating insects. In *Ranunculus* the nectaries (nectar-producing glands) occur in small pockets at the bases of the petals. In some other species the nectaries are considered to be modified petals and in a few cases they are modified sterile stamens.

In columbine, larkspur and monk's hood the flowers have the additional modification of spurs attached to the perianth. The positioning of the spurs, which contain nectaries, ensures that a visiting insect must brush

against the stamens and carpels when it reaches down to collect nectar. In larkspur and columbine the nectar spur is clearly visible in the flower, and the nectar is therefore often robbed by insects, which can perforate the spur and collect the nectar without reaching down into the flower. In monk's hood, however, the spurs are concealed within the 'hood' of the plant's common name and are thus not so obvious to the nectar stealers.

Follicles or carpels The fruits of the buttercup family fall into two groups depending on which subfamily the species belongs to. Those in the subfamily Helleboroideae produce follicles – dry, many-seeded fruits that split open along one side when mature. Some species produce large numbers of follicles from one flower, an example being the globeflower. Others, such as baneberry, bear just a single fruit in which the fruit wall is fleshy.

The other subfamily – Ranunculoideae – contains those species whose carpels mature into a type of dry, single-seeded fruit (called an achene) that falls to the ground instead of splitting open on the plant. The fruits of some plants in the latter group are modified for different methods of dispersal. In traveller's joy and wood anemone, the style becomes greatly elongated and adorned with fine hairs. These plumed fruits are adapted for wind dispersal and give traveller's joy the familiar appearance of 'old man's beard'.

A few species of *Ranunculus*, such as the corn buttercup for instance, develop spines or barbs on the surface of the achene, probably to aid their dispersal by animals.

Some plants with follicular fruits also have unusual methods of seed dispersal. The hellebores, for example, have a fleshy oil-storing body on the surface of their seeds to attract ants, which drag the seeds away.

Left: Some species in the buttercup family have brightly coloured floral parts that attract pollinating insects. An example is pheasant's eye, which combines purple or black stamens with petals that are bright scarlet with a black patch at the base.

Opposite right: Some representatives of Britain's 12 native genera in the Ranunculaceae, with flowering periods. The box, bottom left, shows some of the variations in the shapes of the basal leaves between the different species.

Below: Wood anemones flowering in early spring. The flowers of this species, and those of some others in the buttercup family, are solitary. On others the flowers are borne in an inflorescence, either a cyme (for example, *Ranunculus*) or a raceme (for example, *Aconitum*).

The buttercup family

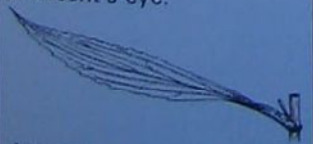
1 Traveller's joy or old man's beard (*Clematis vitalba*). July-August.
2 Marsh marigold (*Caltha palustris*). March-May.
3 Stinking hellebore (*Helleborus foetidus*). January-April.
4 Pasque flower (*Pulsatilla vulgaris*). April-May.
5 Wood anemone (*Anemone nemorosa*). March-April.
6 Globeflower (*Trollius europaeus*). July-August.
7 Mousetail (*Myosurus minimus*). May-June.
8 Common meadow-rue (*Thalictrum flavum*). July-August.
9 Monk's hood (*Aconitum napellus*). May-September.
10 Columbine (*Aquilegia vulgaris*). May-June.
11 Creeping buttercup (*Ranunculus repens*). May-August.
12 River water-crowfoot (*Ranunculus fluitans*). May-September.
13 Baneberry (*Actaea spicata*). May-June.

Basal leaf shapes

Above: Palmate with 3-5 lobes. Example: round-leaved crowfoot.

Above: Reniform or kidney shaped. Example: marsh marigold.

Above: Pinnate and finely dissected. Example: pheasant's eye.



Above: Lanceolate or spear shaped. Example: greater spearwort.

BEACHES: HOSTILE HOMES FOR INSECTS

Beaches provide an inhospitable environment for insects with the alternate flooding and drying caused by the tide, and the strong turbulence of the waves. Nevertheless, a few species can thrive, living on rotting seaweed or sheltering in rocky crevices.

Above: Carnivorous rove beetles (*Cafius xantholoma*) on red seaweed along the shoreline. The adults (6-9mm/$\frac{3}{8}$in long) and larvae of this species are abundant on rotting wrack heaps, although they retreat when the tide comes in and submerges the seaweed. These beetles are the main enemies of seaweed flies, the larvae of which also thrive on rotting seaweed but can withstand immersion in salt water for as long as six days.

Most aquatic insects live in comparatively still waters or along the margins of freshwater ponds, lakes and rivers. Few have succeeded in establishing themselves in fast streams, and even fewer in the intertidal zones of the shore. Although it had been thought that the salinity of the shore accounted for the small number of successful insect colonizers, it now appears that the turbulent action caused by the waves is the main reason, since insect life is usually abundant in saltmarshes and brackish water.

Masses of maggots One insect which has successfully established itself on the seashore is the seaweed fly. Found easily throughout the year, it lives and breeds in the heaps of wrack thrown up along the high tide mark. This rather flattened, blackish, hairy species, not unlike a housefly at first glance, is attracted to the seaweed within a day or so of it being thrown up. When the seaweed decomposes it becomes slightly warmer, encouraging the female flies to lay their eggs in it.

The eggs hatch into legless maggots about one day later; their feeding spreads the decay and heats up the wrack bed again so that more flies are attracted. The entire heap thus becomes a mass of maggots in warm seaweed, able to continue their growth even in the harshest winter weather.

The adult flies also spend a good deal of their life in the seaweed. The time between laying the eggs and the emergence of the adults is about a fortnight, giving ample time for the next generation to be produced before another high spring tide removes the wrack. The larvae are able to withstand immersion in salt water for as long as six days and can be washed out to sea and then returned on fresh weed.

Adult seaweed flies can sometimes be seen carrying out mass migrations along the shore, and in years when their numbers are unusually large they have been found some miles inland; in 1954 some were even recorded in London. (Seaweed flies appear to be attracted to trichlorethylene and carbon tetrachloride, which may account for their occasional invasions of dry cleaners and chemists.)

Beetles on the beach A number of rove beetles belonging to the genus *Bledius* live in the intertidal zone near the high tide mark, feeding on a variety of algae. The females, which dig in the sand where there is a coating of mud have to face not only salinity but also an oxygen shortage. To counteract this problem they constantly dig tunnels; this, with the tidal movements, keeps the tunnels ventilated.

The females lay their eggs in batches in multiple chambers and, showing unusual maternal care, protect the eggs and larvae from intruders until the larvae are large enough to build their own tunnels. If the mother is taken away the eggs and larvae perish.

Bledius species live in colonies and throw up small mounds of sand about 12mm ($\frac{1}{2}$in) high, sometimes making a more or less continuous line for miles. The beetles stay in their burrows when they are covered by the tide. Otherwise they can sometimes be seen flying low in large numbers along the beach. These species are preyed on by an active ground beetle *Dyschirius*, which constantly runs in and out of their burrows.

Crevice retreats A tiny ground beetle, *Aepus marinus*, can sometimes be found running about on stones and seaweed at low water. When the tide comes in it creeps under stones or into rock crevices. This is where you are most likely to come across both the larvae

Left: The seaweed fly (*Coelopa frigida*) and its larvae. The female lays her eggs in batches of approximately 80 on warm decomposing wrack, and within a day or two they hatch into legless maggots. The heat generated by the continued decomposition of the seaweed attracts more flies so that the wrack soon becomes a wriggling mass of maggots.

Below left: Adult seaweed flies can sometimes be seen migrating *en masse* along the shore.

Above: The springtail *Anurida maritima* (left) is preyed on by the tiny ground beetle *Aepus marinus* (right) which is 2.5mm long, and is found running around on stones and seaweed at low water; it is particularly abundant on the south and west coast.

and the adults – usually in local colonies on the south and west coasts of Britain. The larvae are small, pale and, like the adults, are carnivorous, feeding on the crevice-inhabiting springtail *Anurida maritima*.

The larvae of *Aepus marinus* pupate in late summer and spend a fortnight in this stage, deep in the crevices. They appear to be able to withstand immersion in salt water, although it is possible that fissures in the rock have air pockets that help them to survive.

Another crevice-inhabiting insect is the marine bug *Aepophilus bonnairei*, which belongs to the family Saldidae, species of which are regularly found at the margins of fresh and salt water. *A. bonnairei* has no hindwings and only short forewings so it cannot fly. It lives in family groups, typically in slate and shale crevices in the lowest *Fucus* zone (below the neap tide but above low spring tide marks).

The best time to look for this marine bug is around the new or full moon. You should work upwards from the *Laminaria* (kelp) zone, looking in those crevices not too exposed to wave action.

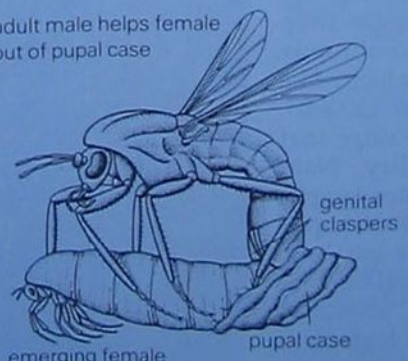
Aepophilus bonnairei is predatory, probably feeding on marine worms – they certainly eat these in captivity. They are fairly sedentary because their crevices are so low down the shore that they have little opportunity for hunting outside. They appear to have areas of minute water-repellent hairs around their spiracles (breathing holes) which trap air so they can breathe under water.

Above: The rove beetle *Bledius spectabilis*, 5-6mm long, is found near the high tide mark in England, Scotland and Ireland.

Shoreline midges A number of midges regularly breed in the intertidal zone and you can often see them in dancing swarms over seaweed. Species of *Clunio* have a particularly intriguing mating sequence. The male emerges as an adult before the female and, on finding a suitable partner, must help her out of her pupal skin before mating can take place; the female is incapable of extricating herself from the pupal skin without the help of the male. During mating the male flies in a series of gliding flights carrying the female with him for five to fifteen minutes at a time (she is unable to fly herself).

Above: *Aepophilus bonnairei*, a marine bug 3mm long, inhabits crevices in slate and shale along the shore.

Mating midges



The larvae of a species of *Clunio*, a seashore midge, live in tubes built on seaweed in rock pools. After pupating the males rise to the water surface and, on emerging, search for a female. Since the females are still in their pupal cases, the males have to remove them before mating. This they do by grasping the females and tearing off the pupal skin with their genital claspers (left).

CWM IDWAL NATURE TRAIL

To follow the NCC Nature Trail that circles the half-mile long Llyn Idwal in North Wales is to enter a world where the effects of the Great Ice Age are everywhere evident – not only in the rocks and land forms but also in the rare and unusual vegetation.

A mile and a half north-east of the peak of Snowdon in North Wales the land drops down cliffs and rocky slopes into the deep Pass of Llanberis, then rises just as abruptly up the flanks of Glyder Fawr which, like Snowdon, reaches to over 900m (3000ft). But the Glyder is only a narrow ridge that soon plunges into the next valley, Nant Ffrancon. On maps or in aerial photographs the Glyder range has a very distinctive shape – all along its north-eastern side it has been carved into a succession of semi-circular hollows about half a mile across, several of them consisting of a horseshoe of high crags overlooking a deep bowl with a lake in the bottom.

Such land forms, often called corries, are a typical product of the Great Ice Age and are found in glaciated or formerly glaciated mountain regions throughout the world. The Welsh word 'cwm', often applied to valleys in general, is also used to mean a corrie.

As you travel along the A5 between Capel Curig and Bethesda the splendid sequence of Glyder corries is on the left. The mountains crowd in close, the most dominant being the craggy peak called Tryfan, which almost overhangs the road. As you skirt Tryfan the most spectacular of all the corries – Cwm Idwal – comes into view. This celebrated mountain hollow (its floor is 365m/1200ft above sea level) is reached by a footpath half

Above: A winter view of Cwm Idwal and its lake. A million years of rubbing and tearing by a great weight of ice and frozen rocks gouged out this, and other, corries in the area.

a mile long, beginning near the youth hostel at the western end of Ogwen Lake. At first the track climbs away to the left, as if making straight for Tryfan, but it soon swings to the right, climbing gently all the way until you top a rise and look down into the floor of Cwm Idwal with Llyn Idwal just below. It is here that the nature trail both begins and ends, for it takes you on a circuit of the lake by way of 12 viewing stations (as described in the booklet issued by the NCC).

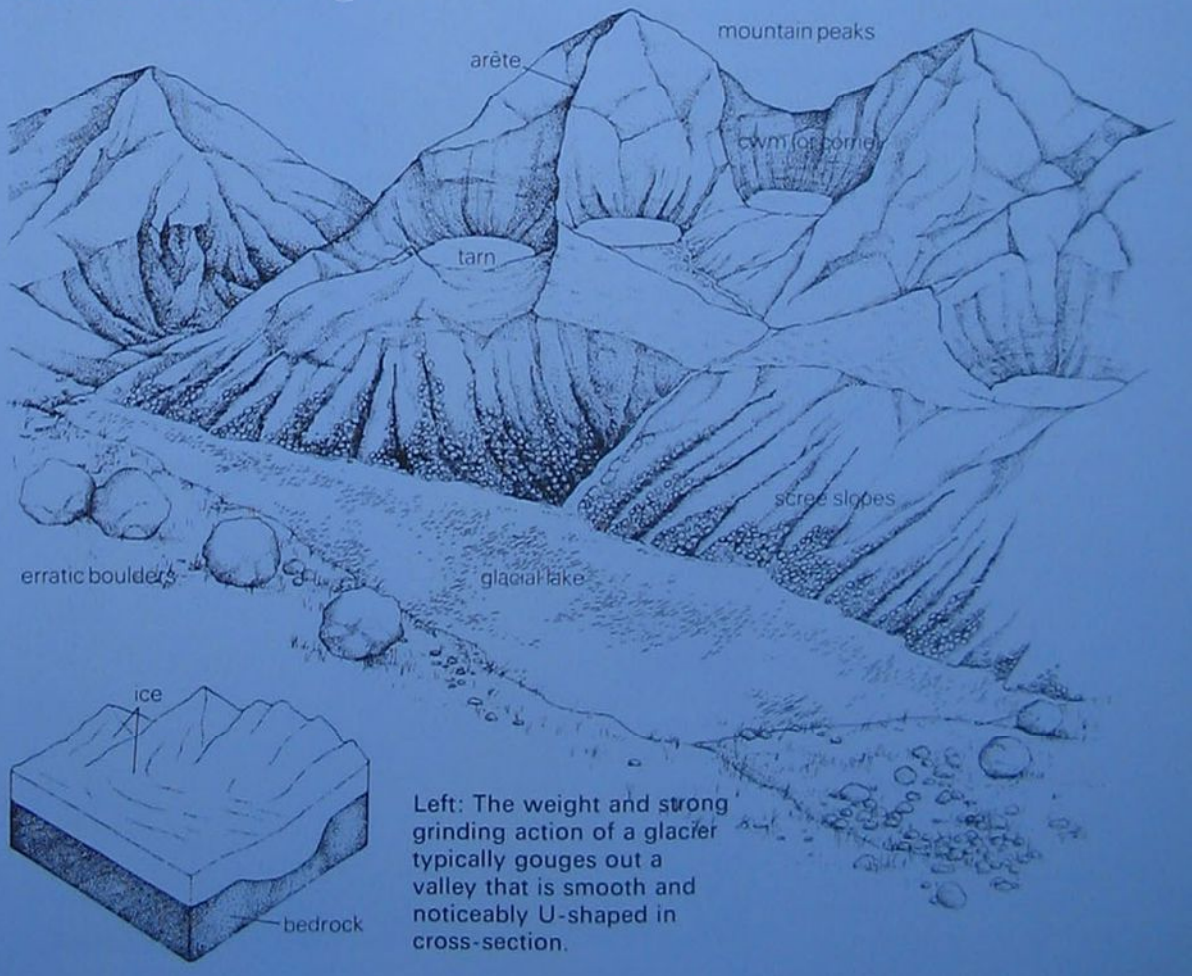
Evidence of glaciation The start of the trail is a perfect spot from which to contemplate the immense impact that erosion has had on the mountain landscape since Snowdonia began to rise above sea level after the Silurian period. Look especially at the rocks on either side of the vertical chasm called Twll Du (Devil's Kitchen) and you will see how the strata there form a downfold (or syncline), suggesting that those cliffs were once rocks deep inside some vast mountain range that has been almost completely eroded away.

The time needed to wear down those ancient mountains to their present stumps was three hundred million years. In comparison, the hollowing out of Cwm Idwal and other corries was quickly accomplished–it took a mere one million years of rubbing and tearing by an immense weight of ice (with rocks frozen into it) which gouged through the cwm on the way down to Nant Ffrancon. The rocks now scattered all over the floor of Cwm Idwal are also unmistakable evidence of the Ice Age. Many lie so far from the cliffs that they could not possibly have rolled there: they are rocks frozen into the glaciers and left on the ground when the ice melted.

The trail, which goes anti-clockwise round the lake, brings you first to a vantage point that looks down Nant Ffrancon towards Bethesda, a view that includes more evidence of Ice Age work. Nearby are outcrops of rock that still show their glacier-smoothed surfaces. And down the sides of the valley there are the deposits of ice-carried rock debris called moraines. The remarkably level floor of Nant Ffrancon, so green and fertile compared with the thin-soiled, heathery valley-sides, was once a long, narrow post-glacial lake which has been silted up by sediments washed down from the uplands. In cross-section Nant Ffrancon has the perfect U-shape so typical of glaciated valleys.

Grazing and fenced enclosures For many centuries Cwm Idwal has been grazed by domesticated sheep (still there in abundance), and by goats, of which only a few are left, living quite wild and independent lives. Inevitably all this grazing has had a profound effect on the vegetation. To illustrate this the NCC, in the 1950s, erected small fenced enclosures on a slope near the lakeside, so that the close-nibbled turf of sheep's fescue and mat-grass outside the enclosures could be compared with the jungle of long grass and

The effects of glaciation



Right: All the glaciation features shown here occur in the Cwm Idwal area. The passage of a large glacier down the mountainside gouges out a series of semicircular hollows called corries or cwms, leaving knife-edge arêtes or ridges in between. The corries may contain a tarn, or they may be dry. As the ice melts it deposits the soil, rocks and other rubble it carries in a series of moraines–low mounds or hillocks. Larger boulders–called erratics or perched blocks –can be left stranded miles from where they started. A glacial lake, too, may remain at the foot of the mountain.

Left: The weight and strong grinding action of a glacier typically gouges out a valley that is smooth and noticeably U-shaped in cross-section.

Left: Bogbean grows on the marshy edges of Llyn Idwal.

heather inside.

In the course of time there may also be rowan trees growing inside the fence, trees sprung from berries carried there by birds. Or there could be birches whose lightweight seeds might be hurled up into the cwm by gales. Any trees in this corrie are a reminder of the native woodland that formerly covered much of these uplands.

The lake shore The marshy parts of the lake edge are a habitat for many kinds of plants, such as the lesser spearwort, bog bean, marsh cinquefoil and two insect-eating species–round-leaved sundew and common butterwort. Corrie lakes are often very deep but, at 9m (30ft) in the middle, Llyn Idwal is comparatively shallow, especially at the south end where there are sheets of bottle sedge, horsetails and other water-chokers. The rosettes of narrow leaves you see widespread in the shallows on the lake bed are mostly those of water lobelia.

Stand quietly anywhere at the lake edge and you will see shoals of minnows swimming restlessly back and forth in the clear water, the dark bar along their flanks distinguishing them from the young brown trout which also keep to the shallows. These plentiful fish attract herons and cormorants all year round. In winter, if the lake is not frozen, there are usually a few mallard, goldeneye, pochard[L] and occasionally whooper swans. In summer a pair or two of common sandpipers nest on the shore, while grey and pied wagtails and black-headed gulls also occur.

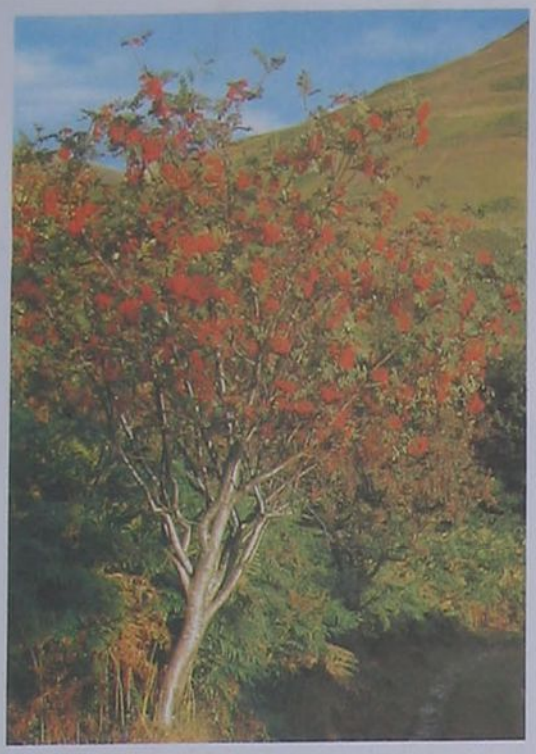
Among other breeding birds of the cwm are many meadow pipits on the grassland and a scattering of wheatears among the screes; and from heathery crags you can often hear the croaking of ravens and the piping of ring ouzels. After the breeding season, especially from July to September, the most distinguished bird here is the chough.

The trail follows the lake-edge to the top of some artificial-looking mounds which you might suppose are the spoil heaps of some old mine. But there has been no mining in Cwm Idwal and these hillocks are in fact glacial moraines. They have long since greened over and in their turf you can find three of the four

Right: The Idwal Slabs. Where the Idwal nature trail curves round the south end of the lake there is a sharp change in the look of the cliffs. Now, instead of the broken precipices of the Devil's Kitchen and the boulder scree below, you can see a sweep of grey rocks coming steeply down for hundreds of feet, ending nearly at the Idwal Slabs, formed of lava from the Ordovician volcanoes. Extremely hard, they have not been shattered into crags and screes and present a polished face to the world (although they are not so smooth as to be totally devoid of minor cracks and fissures). Because they do offer hand and toeholds, and because they are far from vertical, the Idwal Slabs are popular as nursery cliffs among climbing novices. And since they are hard, limeless and dry these lavas (called rhyolites) have a sparse flora, the most likely plants being bilberry, wavy hair-grass and heather.

Above right: An adult cormorant at its nest, with two juveniles. The plentiful trout and minnows in Llyn Idwal attract these birds all year round.

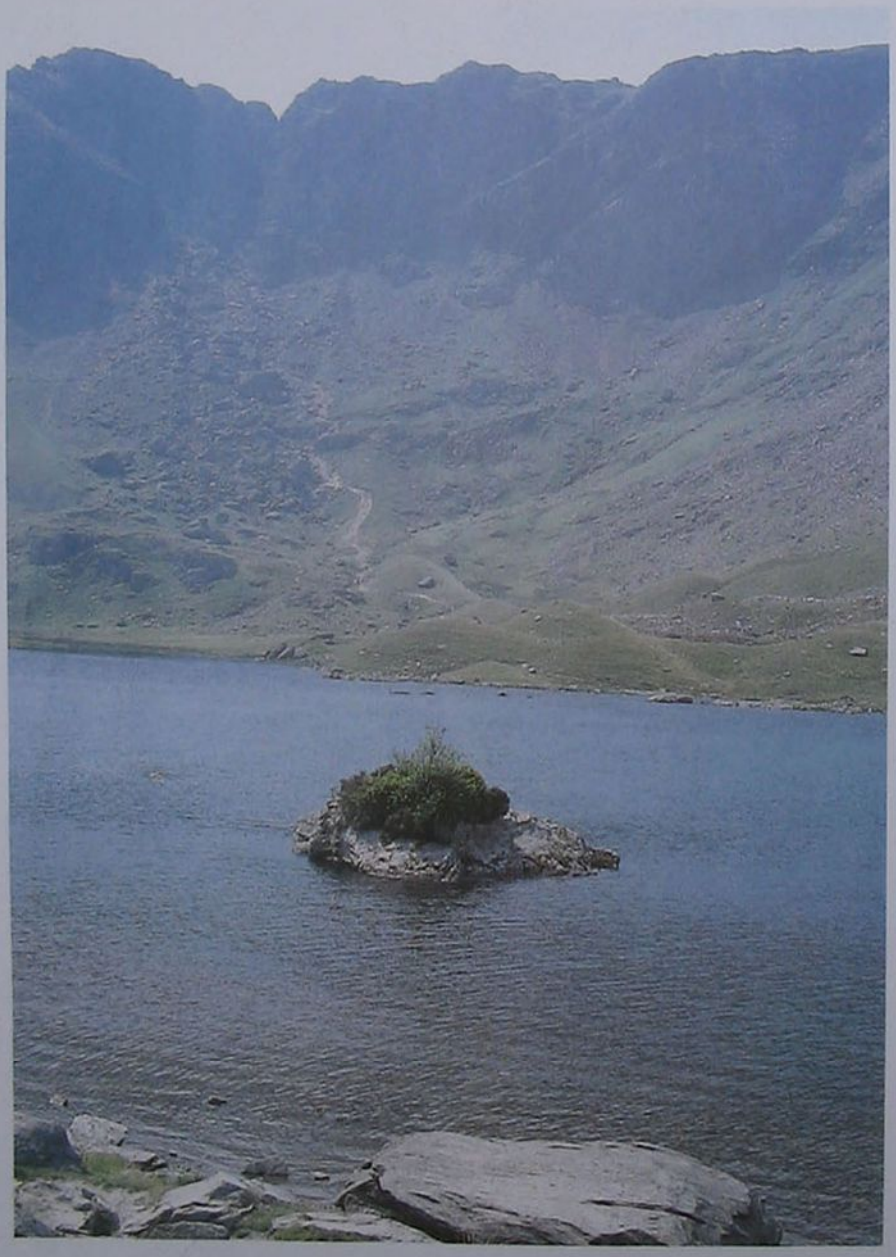
Right: Roseroot—one of the alpine plants to be found in Cwm Idwal. The cliffs of this area were among the first where alpine plants were studied in Britain, for at that time (the 17th century) other mountains, especially those in Scotland, were too remote for botanists to reach.



Left: A rowan laden with berries in early autumn. You may see this tree where sheep are excluded from grazing in Cwm Idwal.

Right: Mountain sorrel growing near the Devil's Kitchen in lime-rich rock.

Below: There is a large 'island' boulder in Llyn Idwal which is out of the reach of grazing sheep and goats and is consequently completely clothed with heather, bilberry, polypody ferns, mosses and several rowan trees—an excellent indication of what the vegetation would be like all over the floor of Cwm Idwal if it were not for these grazing animals.



mountain clubmosses: the fir clubmoss, the stag's horn and, especially common, the alpine clubmoss.

The alpine flora From these moraines the trail guide draws our attention to the steep slopes above this side of the lake. They are the lower skirts of one of the Glyder peaks –Y Garn–which is hollowed into by a high-placed corrie called Cwm Clyd. There are in fact two corries, one above the other, linked by a stream which plunges from Cwm Clyd to Cwm Idwal down an almost precipitous gully. Perched high above its neighbouring corrie, Cwm Clyd is a fine example of another well-known glacial feature, a hanging valley.

Cwm Idwal can claim great distinction as a botanical site. Some of its cliffs are as rich in mountain plants as anywhere in Wales. Many of today's British alpine plants were widespread in the lowlands in the tundra conditions existing immediately after the Ice Age. But as the climate became warmer they were ousted from the low ground by broad-leaved forests and other types of vegetation which thrive in temperate conditions. What now survives of the old tundra flora is found almost exclusively on the mountains.

Many of these alpine plants require very special sites: they need rather soft rocks full of crevices and cool ledges where water oozes and trickles all through summer; and these rocks must contain plenty of available lime. Such conditions are rare in Wales, but they are found perfectly in the wet, north-east facing Devil's Kitchen cliffs with their comparatively soft, lime-rich igneous rocks. Alpine plants are easiest to find in the gullies in and below the cliffs. The commonest include starry saxifrage, mossy saxifrage, roseroot and mountain sorrel.

Also to be found is a group of mountain plants which do not demand lime in the soil. They include crowberry and cowberry, parsley fern, the three common clubmosses and a grass called viviparous fescue.

As the trail circles back along the east side of the lake you can look across to the other side for a view of the ground you have covered–the grasslands, the heath and peat, the hummocky moraines and the scree slopes.

FERNS OF CHALK AND LIMESTONE

Several of our most attractive ferns can grow only in a basic, calcium-rich soil. Some are confined to upland regions but others, less demanding in their requirements, have colonized man-made structures such as old walls and bridges.

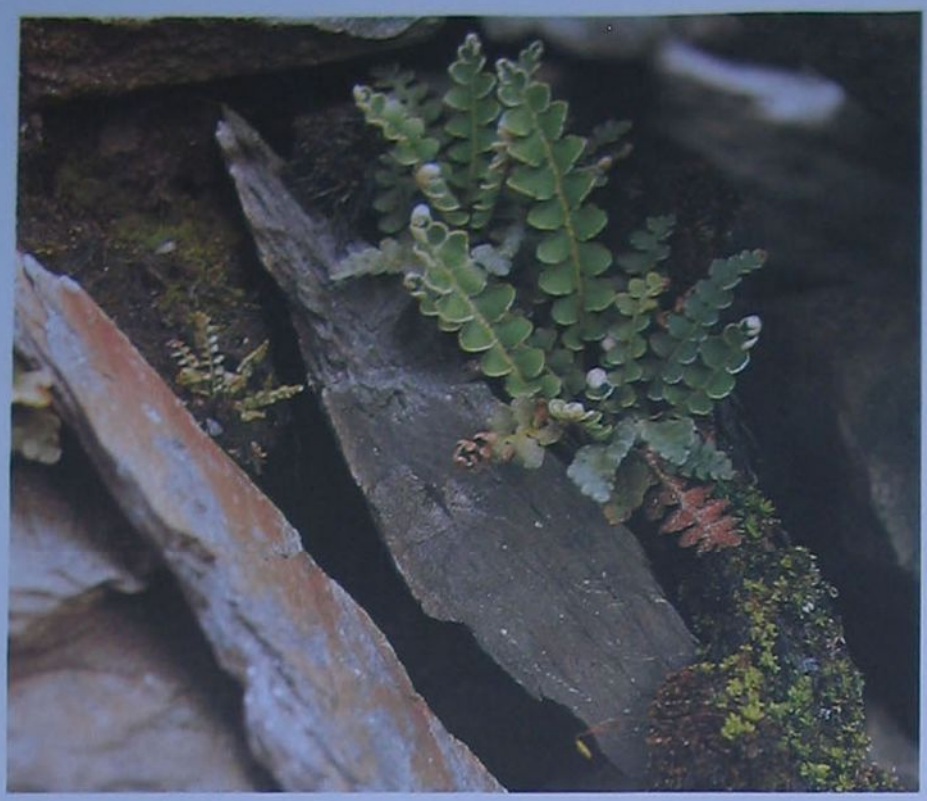
Below: On rocks and old walls of south-western Britain and Ireland you may see the southern polypody (*Polypodium australe*), a species with a creeping rhizome bearing once-pinnate fronds at intervals.

Like many well-known flowering plants, such as traveller's joy and deadly nightshade, that are characteristic of basic or alkaline soils, some ferns grow only in places reasonably rich in calcium carbonate. Such habitats are known as basic, as opposed to acidic, and species growing chiefly or entirely in them are said to be calcicolous (meaning lime-loving).

Such ferns can, of course, grow in basic habitats only when other environmental factors such as moisture and temperature are also suitable. For instance, chalky areas are basic but they are normally too dry for calcicolous ferns to establish themselves, whereas many calcicolous flowering plants successfully grow there.

Bladder ferns Several calcicolous ferns are to be found in mountains and other upland regions. One such group is the bladder ferns. They acquired this curious name because of the delicate covering called the indusium which protects the groups of spore capsules (the sori) on the undersides of the fertile fronds. In the early stages of development the indusia are clearly seen to be hood-shaped and inflated. As the spore capsules mature, however, the indusia wither and become inconspicuous.

The commonest of our three species of bladder fern is the brittle bladder fern, which is found mainly in northern England, Scot-



land and Wales. The other two species are much rarer: Dickie's bladder fern is a protected species whose only definitely known habitat is caves by the sea in eastern Scotland, and the mountain bladder fern is found only in the central Scottish Highlands.

All three species have small, delicate and finely divided fronds, 10-20cm (4-8in) long. Those of the brittle and Dickie's bladder ferns are spear-shaped, while the fronds of the mountain bladder fern are triangular.

Holly and hard shield Another fern of basic upland areas is the holly fern, so-called because of its stiff, leathery dark green fronds. These grow to a length of 15-30cm (6-12in) and are once-pinnate (like the leaf of an ash tree) and very narrowly blade-shaped. This rare fern is found mainly in central and north-west Scotland, but also in western Ireland, north Wales, northern England and the south of Scotland.

Another species in the same genus, *Polystichum*, also needing a basic soil is the hard shield fern. Unlike the holly fern, this species is widespread throughout the British Isles, though more common in the north. As well as growing in rocky woods beside streams, it is also found on limestone pavements and rocky screes on mountain slopes. It produces fronds in a basket arrangement – as does the holly fern – but they are usually broader and much longer than those of the holly fern – up to 60cm (2ft) – and bi-pinnate, ie each pinna ('leaflet') in the frond is itself pinnate.

Like all species in this genus, the holly fern and the hard shield fern have small round indusia attached at the centre to the middle of the sorus.

Limestone species Apart from the hard shield fern, several other species live on limestone outcrops. The aptly named limestone fern is found at moderate altitudes, mainly in Wales and England. The fronds grow singly from a creeping rhizome and reach a length of 20cm (8in). They are triangular in outline and very finely divided, giving the fern a delicate feathery appearance. The blade of this fern is covered with glands that give off a sweet scent when the frond is rubbed.

A rare fern of limestone pavements, screes and crags of northern England is the rigid buckler fern. Its bi-pinnate fronds grow to 20-60cm (8-24in) long in a shuttlecock arrangement. They are rather rigid with a floury appearance caused by the yellowish glandular hairs covering the surface of the fronds. When bruised the fronds give off a scent similar to that of balsam.

Ferns of walls and bridges Several of the species mentioned so far have restricted distributions. For example, the holly and limestone ferns are both found elsewhere in the world only at high latitudes in the Northern Hemisphere – a distribution known

Above: The rustyback fern (*Ceterach officinarum*) derives its common name from the undersides of the fronds, which are covered with scales that turn a rusty brown with age.

Below left: The rigid buckler fern (*Dryopteris submontana*) is found only on limestone pavements, screes and crags of northern England.

Below right: The fronds of the rare holly fern (*Polystichum lonchitis*) grow in a shuttlecock arrangement from an upright central stem.

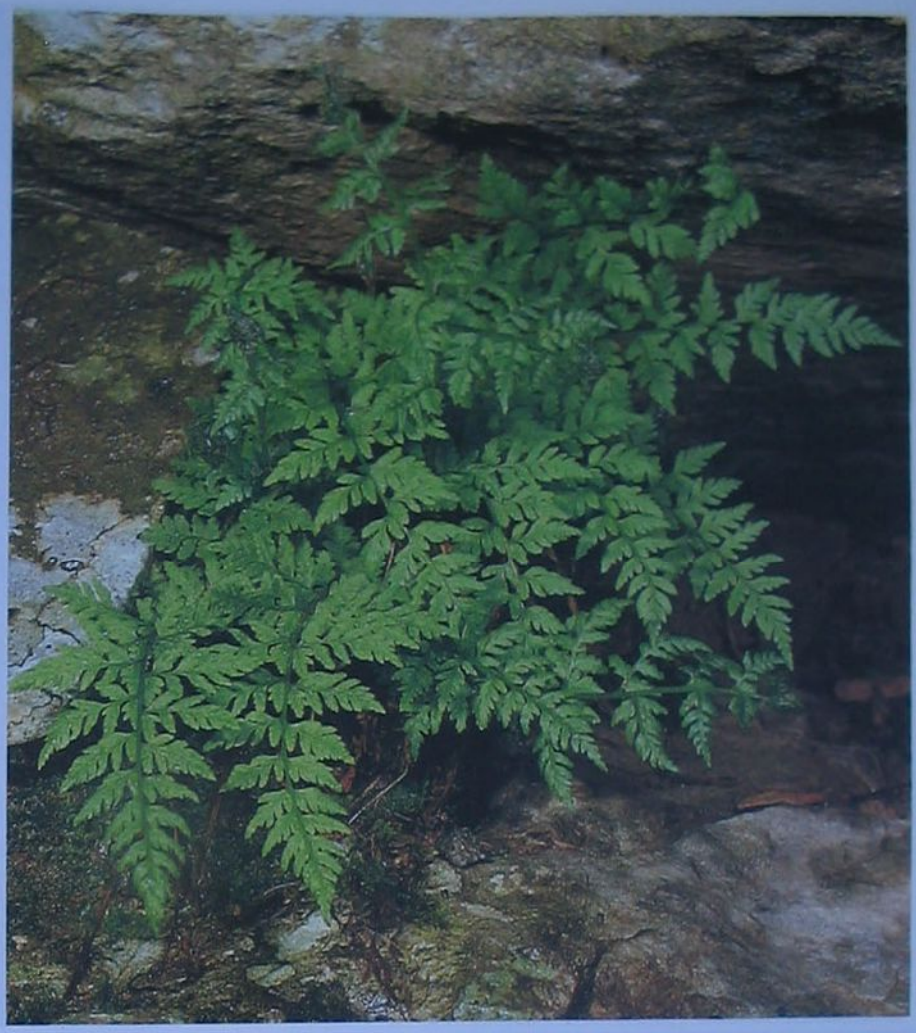
as circumpolar.

Other calcicolous ferns, however, are less restricted in their environmental needs and are able to grow on man-made structures. Old walls, railway bridges and the sides of canals where the calcium-rich mortar is crumbling provide ideal sites for such ferns. The brittle bladder fern is one of these, as are several species of spleenwort. This group of ferns, which belong to the genus *Asplenium*, are characterised by long, narrow sori, protected when young by similarly shaped indusia. Two of these species, the green and maidenhair spleenworts, look very similar to each other, both having pinnate fronds with almost parallel outlines. They can be told apart by their stalks: they are green on the green spleenwort and brown on the maidenhair spleenwort. Also, the fronds of the latter are generally longer, growing to a length of 35cm (14in) compared with 20cm (8in) for the fronds of a green spleenwort.

Other spleenworts growing on these man-made habitats are the black spleenwort and the wall rue. The former has long (up to 45cm/18in) much-divided fronds while the latter is the smallest British spleenwort, its fronds reaching a length of 12cm (5in) though they are usually much smaller. Indeed, at first glance it can be confused for a sporeling (ie, young) plant of the black spleenwort.

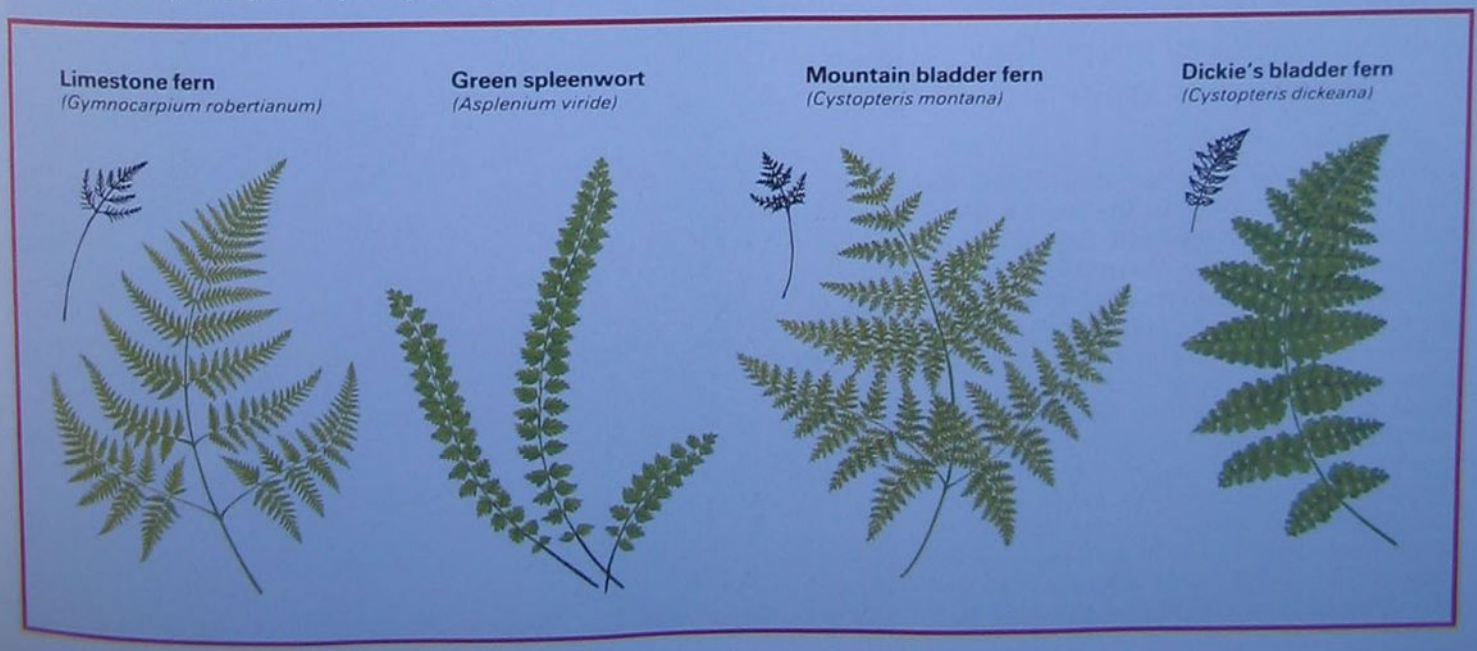
Rustyback and hart's tongue Several species of fern other than spleenworts share the same brickwork habitat. Among these are two species closely related to the spleenworts. The rustyback fern has deeply divided, almost pinnate fronds, whose lower surfaces are so densely covered in scales that the sori are almost completely hidden. Usually there are also a few scales on the upper surfaces. The other species is the hart's tongue fern, named after its long leathery fronds. It is one of the few ferns able to establish itself in the heart of cities.

Two other species you may see growing on brickwork are the southern polypody and the maidenhair fern. The former is found mainly in Ireland and the western part of southern Britain. Its once-pinnate fronds are borne at intervals along a creeping rhizome. The maidenhair fern (no relation to the maidenhair spleenwort) is a house plant but not at all common in the wild. It is confined mostly to the coast at a few localities in the south-west of England, south Wales, north-west England and western Ireland.



Above: The brittle bladder fern (*Cystopteris fragilis*), so called because of the way in which the fronds break off some distance from their bases, is the commonest of our three bladder ferns.

Below: Four species of ferns found on basic substrates.



TWENTIETH CENTURY URBAN FOX

Urban foxes are increasing in numbers, according to studies in Bristol and other areas. For many people they are welcome visitors.

Above: A pair of foxes sunbathing on the roof of a shop in Bristol and (below) a fox taking a day-time stroll. In the 1950s and early 1960s foxes spread rapidly in many towns and cities and urban foxes have been a common sight for the last 20 years.

Urban foxes are now well established in many towns and cities in the British Isles, particularly in Glasgow and Edinburgh in Scotland, and in most towns and cities in England from Nottingham southwards. They are rare in the north of England.

Their appearance in our urban areas has been a relatively recent phenomenon; the rapid development of low density housing suburbs in the inter-war years provided an ideal habitat for the fox, and by the end of World War II several towns had foxes living on their fringes. In fact, by the early 1950s foxes were considered to be a pest in the Kent and Surrey suburbs of London and the Ministry of Agriculture was shooting over 100 animals each year. In the 1950s and early 1960s urban foxes spread rapidly and they continue to be a common sight.

Fox populations In many areas foxes attain higher densities than in the surrounding rural areas. Up to five fox families per square kilometre have been recorded in Bristol, parts of the West Midlands conurbation and Bournemouth and Poole. These high densities are always found in the areas of inter-

war housing. Smaller towns and cities generally seem to have lower fox densities, but at present no-one knows why this is the case.

Foxes live in family groups and these usually consist of a dog fox, a breeding vixen and, in some cases, perhaps one or two non-breeding vixens which are related to the breeding vixen. Usually these barren animals are daughters, but occasionally they may be a sister or, if the original mother reaches old age, she may cease to breed and be replaced by one of her daughters.

In Bristol research showed that for every three vixens that breed each year, one does not, and so one in three fox families will have a barren vixen living with them. A detailed survey showed that there were 211 families living in an area of 116 square kilometres (45 square miles); these consisted of 211 dog foxes, 211 breeding vixens and 74 barren vixens–496 adult foxes in all. Since the average litter size is 4.8 cubs, these 211 families could produce 1013 cubs each year. For comparison, similar densities were recorded in the West Midlands conurbation, where there were 683 fox families in an area of 589 square kilometres (227 square miles), and Bournemouth and Poole which had 144 fox families in an area of 83 square kilometres (32 square miles).

Urban fox menus The diet of these urban foxes consists mainly of scavenged food from rubbish heaps and food put out specially for them. The survey showed that the diet of the Bristol foxes was supplemented by small birds, a few wild animals such as squirrels and short-tailed field voles, windfall fruit, insects and earthworms. Predation on pets was comparatively rare. For example, foxes killed only 0.7% of the cats found dead; this works out at 0.17 cats per adult fox each year. Since most foxes may encounter several cats each night while out foraging, this number is incredibly low. In most encounters foxes and cats treat each other with total indifference and in the fights witnessed from start to finish all were started by the cat and all resulted in the fox turning tail and running.

By comparison, the diet of foxes in London was very different. Scavenged food only formed 34.8% of the adult diet, the foxes instead taking more wild mammals and birds, particularly small garden birds and feral pigeons. These birds were particularly important to young cubs, forming about 45% of the diet. Why foxes in two apparently similar situations should exploit such very different food sources is uncertain, but it may be a reflection of the attitudes of the local residents. In Bristol the foxes are not officially regarded as pests by the local Council, whereas many London boroughs undertake fox control. These differing attitudes by the local authorities may be reflected in the willingness of the residents to feed and encourage foxes.

It is difficult to understand why some people and some local authorities should be so strongly anti-fox. As the surveys in Bristol showed, even in an area where foxes are very numerous, losses of pets and tipping out of dustbins are relatively unusual events, and keeping small pets in properly constructed cages or putting a clip on the dustbin lid easily eliminates such problems.

Cubs under the garden shed Town foxes may create more of a nuisance during the breeding season. Peak mating time is in January, when the foxes are at their most vocal. Their barking and screaming calls carry long distances, particularly on cold, clear nights. Pregnancy lasts an average of about 53 days, and in the latter part of pregnancy the vixen

Above: A six-week old fox cub in a suburban garden. Adventurous fox cubs get themselves into a variety of predicaments and often have to be rescued.

Below: This traditional view of the urban fox was not borne out by a survey in Bristol. In over 5500 households 81% of the occupants never had their dustbins touched, and in only 2.7% of the households were foxes a regular problem.

will select an earth in which to rear her cubs.

One of the most popular sites for the earth is under a garden shed that is raised off the ground on a single row of bricks. The vixen squeezes under the shed and her cubs are born on the bare soil. Unlike badgers, foxes do not collect any bedding. Sometimes the vixen digs an earth in a flower bed, a rockery or in a railway bank. She may even bear her cubs under the floor-boards of an occupied house.

In many old houses there are broken air bricks through which the fox can squeeze and, once in, it is an ideal site for the vixen to bear her cubs. In early May, when the cubs are about five weeks old, they start to play and then there is mayhem under the householder's feet as the cubs chase, fight and growl at each other. This activity raises clouds of dust that may rise through the joints of the floorboards and settle throughout the house. Just to add to the general effect, the adult foxes are busy bringing food back to the earth for the cubs, much of which may remain uneaten and slowly decompose. So the house fills with flies and the smell of both rotting food and accumulated urine and faeces. Not surprisingly, most people who have suffered such an experience make sure that they repair any missing air bricks before the onset of the next breeding season.

The cubs normally move out of their natal earth in early June and from then onwards they lie above ground in dense vegetation, or

Above: A fox outside its earth overlooking a railway line near Bristol, and (right) a fox resting under a garden seat. Since there are so many foxes in some towns, there must be ample food to support them. In Bristol, for instance, the majority (61%) of food is 'scavenged': lumps of meat, fat and bones that people put out in their gardens to feed their foxes. One person alone puts out 11kg (24lb) of best meat each week! Foxes also take potato peelings and similar items obtained from compost heaps, and sultanas, bread and bird seed left for garden birds. The foxes rarely touch dustbins or prey on pets. The survey showed that of the households that keep such animals as rabbits, guinea pigs, ducks and chickens, only eight per cent annually suffered any loss. As most of the pets were kept in poorly constructed cages, the foxes could have taken them all if they had wanted.

under piles of rubbish. The whole family group meets at these play areas and the young cubs chase and play with one another, already showing many of the behaviour patterns seen in the adult foxes. The cubs pounce with their fore-feet to pin imaginary mice to the ground, or stand on their hind feet and push each other with their fore legs in mock fights.

The adult foxes also bring various play items back for the cubs. Tennis, rubber and golf balls are particularly favoured, as are food wrappers, and outside one earth in Bristol there were over 40 Kentucky Fried Chicken boxes. Playful fox cubs have been known to pull washing off lines, chew or steal shoes and boots left outside the kitchen door, jump on to and break the glass tops of seed incubators, and chew plastic plant cloches. They also like to chase each other around vegetable patches, and several get hung in garden netting each year. Some fall down inspection pits in garages, others enter houses through cat-flaps and once inside panic and cannot find their way out.

The cubs disperse in autumn. Dispersal may start in late September, but late October until the end of January is the main period for dispersion. Many cubs move away from the city centre and some may leave the city entirely. For instance, two fox cubs born in Bristol moved 18km (11m) to settle on the wind-swept tops of the Mendips. As a general rule, the higher the population density the lower the dispersal distance, and so foxes living at high population densities in cities tend to move short distances. In Bristol dispersal distances of over five kilometres (3 miles) are rare, and many are less than one kilometre. Also cubs born in the city centre tend to move shorter distances than those born near the edge of the city, and they also start to move later.

Above: A fox in a garden in Birmingham. In towns foxes face a number of population pressures and about 60% die each year. At first sight this may appear a very high mortality rate, but for foxes it is comparatively low. In many rural areas up to 80% die each year. In towns the major cause of death is the motor car.

Below: A fox has found its way into a chicken coop.

In towns foxes face a number of population pressures and about 60% die each year. Many are run over, particularly during winter when the cubs are dispersing and the adults mating. Research in London showed that 27.5% of all the foxes had healed bone fractures which were probably the result of car injuries. Foxes also suffer from more direct man-induced mortality. Even in towns they are snared, dug out or caught with dogs, mainly for the price of their skins. Some town Councils still shoot or trap them as pests, although fortunately most take a more enlightened view and leave them alone.

Living in close contact with domestic pets means that foxes are in an ideal position to contract a number of canine diseases. For instance, many town foxes carry antibodies to canine parovirus, which was very prevalent a couple of years ago. In Bristol many are also infected with *Leptospira canicola*, a bacterium that causes chronic renal disease, and in older foxes there may be extensive kidney damage.

In some towns, particularly parts of London and in the south-east, the foxes suffer from mange, an extremely unpleasant disease. It is caused by the sarcoptic mite, which burrows into the skin, causing severe irritation. The fox may lose up to half its body weight, and invariably dies within three to four months. It is widely believed that this disease is so prevalent in urban foxes because their diet is deficient in a number of vitamins as a result of scavenging. This is not true. It is just that since the foxes can live at such high densities in towns it is easier for such diseases to spread. Even then mange is not seen in all urban fox populations. In Bristol, for instance, the disease is totally absent, and the animals look at least as healthy as rural foxes.

OIL, BLISTER AND CARDINAL BEETLES

Soft-bodied, slow-moving, conspicuous and highly distasteful, the oil, blister, flower and cardinal beetles are all closely related–a point determined by the fact that they all have one less joint in their hind legs than other beetles.

Oil beetles have long interested entomologists because their larvae are nest parasites of solitary bees and because they have an unusual life-cycle, undergoing several changes of form. A number of species have been found in Britain, but only *Meloe proscarabaeus* is at all common.

Clumsy black beetle Large, fat and cumbersome, the female oil beetle *Meloe proscarabaeus* reaches 3.2cm (1¼in) in length, although the male is smaller. Both sexes are completely black in colour, sometimes with bluish or purple metallic reflections, and have fairly long legs, making them a conspicuous sight as they walk slowly on grassy downs, banks and heaths between March and May.

Neither sex has hindwings so they cannot fly, while their forewings are shorter than usual, and more or less oval in shape, overlapping at the base–an unusual feature.

Hitching a lift The female oil beetle lays vast numbers of eggs in batches in crevices in the ground. These hatch into minute hard-skinned larvae, which have six longish legs and projecting bristles at the ends of their bodies. Known as triungulins (because their tarsi have three claws instead of the usual two), they are extremely active, and immediately after hatching scatter over the foliage, generally moving upwards on to flowers.

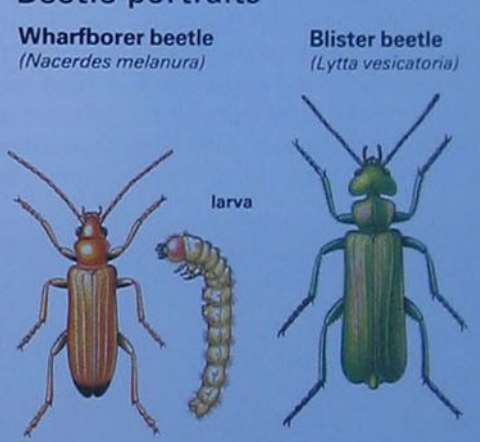
When on the flowers they attempt to hold on to any moving object, but only those which choose an *Anthophora* bee have any chance of survival; many perish without even reaching the flowers, while others cling on to the wrong insects, perhaps other species of bees, or flies if they are sufficiently hairy. This failure rate explains the vast numbers of eggs laid by the female.

The triungulins which cling to male *Anthophora* bees appear to transfer to females when the bees mate, as only the female can take them back to her nest. On arrival at the female bee's nesting tunnel, the triungulin drops into a cell and searches for the bee's egg. This it finds floating on top of a liquid honey and pollen mixture which the adult bee has laboriously collected as food for its own larvae. Predictably, the triangulin then consumes the bee's egg, taking about a week to do so.

Having feasted on the bee's egg, the triungulin casts its skin and completely alters its appearance, becoming rather fleshy with short legs. In this form it feeds on the pollen and honey (taking approximately a month to finish); when no food is left, it casts its skin

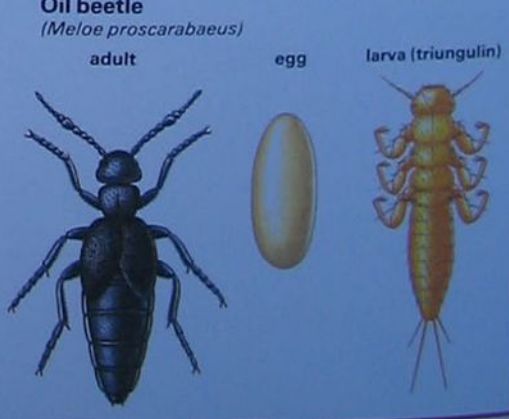
Above: The oil beetle defends itself by producing oily drops of blood from its mouth and pores at the wing-bases and leg joints. This substance is corrosive and unpleasant to taste, justifying the beetle's black warning coloration.

Beetle portraits



Life-cycle

The female oil beetle *Meloe proscarabaeus* lays 3000-4000 eggs in batches in crevices and holes in the ground. These hatch into hard-skinned larvae, known as triungulins, which disperse rapidly over the foliage. From here they try to catch a lift from *Anthophora* bees, on whose eggs, pollen and honey they feed in the bee's nest.



Above: *Oedemera nobilis*, the commonest British flower beetle, is 8-10mm (⅜in) long, and is often seen on such flowers as ox-eye daisies in summer.

again and changes into a legless form–a condition in which it rests through the summer and autumn.

In late winter or early spring it again changes shape, becoming more like the second stage for a few days, before pupating. The adult oil beetle finally emerges in early spring.

Medicinal use The blister beetle is rare in Britain, being found only occasionally in the south-east on bushes and trees. At 12-20mm (½-¾in) long this striking iridescent green beetle is quite closely related to the oil beetle, although it possesses wings and better developed wing-cases that enable it to fly. The blister beetle appears later in the year than the oil beetle, generally in June or July, but it has a similar life-history, with the larvae feeding in the nests of solitary bees. The triungulins remain lethargic until spring, when they actively seek bees to carry them to their nests.

Blister beetles contain cantharidin in their bodies, a potent blistering agent which sufficiently deters would-be predators. At one time cantharidin was widely used as a medicinal blistering agent, the drug being obtained from the beetle's wing-cases, which contain the highest concentration of cantharidin.

Flower-beetles The flower beetles belong to a related family, the Oedemeridae. *Oedemera nobilis*, the commonest British species, is 8-10mm (⅜in) long and metallic green in colour with rather narrow wing-cases.

These beetles are often seen in summer on flowers, giving you a good opportunity to observe the male's thicker hind femora–an important feature during mating. The soft-bodied larvae have a simple life-cycle, developing in wood or thick plant stems.

Another member of the family Oedemeridae is the wharfborer. Yellowish to reddish-brown in colour with black-tipped wing-cases, it is most unlike other members of the family, resembling more closely the common soldier beetle (to which it is not related).

The name 'wharfborer' comes from the larvae, which live in rotten wood and are particularly common around wharves and docks. Curiously, the beetles sometimes appear in large numbers in town houses and offices far from water–a foreboding sign which indicates the presence of rotting wood.

Scarlet-coloured beetles The last group, the cardinal beetles, belong to the Pyrochroidae family, and are rather flattened beetles in which the wing-cases and body become broader at the hind end. Two species found in Britain are *Pyrochroa coccinea*, with a black head, and *Pyrochroa serraticornis*, with a red head. Both occur in June on flowers at the edges of woodland and they are extremely sluggish–a feature which, combined with their colour, indicates distastefulness.

The larvae, which have a simple life-cycle, are easily distinguished since they are flattened and yellowish-brown in colour.

Below: Cardinal beetles belong to the family Pyrochroidae, a name which derives from the striking scarlet colour of their thoraxes and wing-cases. Two species often seen in this country are *Pyrochroa coccinea* (left) which is distinguished by its black head, and *Pyrochroa serraticornis* (a pair of which are shown mating below), which has a red head. Notice their comb-like antennae. Both species are found in June on flowers or under loose bark on dead broad-leaved trees at the edges of woodland.

BIRD ANATOMY: DESIGN FOR FLIGHT

Birds are masters of the air and display a range of adaptations which improve their powers of flight. Here we look at their remarkably airworthy anatomy, and at their advanced physiology, with 'supercharged' systems of breathing and blood circulation.

A comparison of the anatomy of some present-day reptiles, of some of the smaller dinosaurs and of birds suggests that birds developed many millions of years ago from dinosaur stock. But there are some fundamental differences: whereas dinosaurs were covered with scales (as are modern reptiles), birds have developed these into feathers. An even more radical change occurred when birds became warm-blooded. So perhaps we should regard birds as 'supercharged' reptiles, more active and more sophisticated, but with the increased consumption of energy that goes with a high output of power.

The many uses of plumage Feathers are unique to birds. Formed from a protein known as chitin (pronounced kite-in), they are strong yet flexible, and are easily replaced if worn or damaged, for birds moult regularly and grow new feathers. They are warm and often water repellent, light in weight, and an ideal medium for the vast array of plumage colours and patterns featuring in birds' display activities.

Above: A colony of black-headed gulls in flight. Mass flights are thought to help stimulate breeding in colonial bird species. Birds derive countless advantages from their ability to fly. Not only can they escape from predators and other danger; they are also able to range widely over a local habitat, and to colonize new habitats. Flight also gives them the power of migration, and various bird species feed, display, mate and even sleep on the wing.

Feathers are secreted by special cells in the skin, rather resembling the follicles that produce our hairs. In most birds the complete set of feathers is renewed once each year. Some feathers, such as those cladding the body, are light and small, best suited to producing a streamlined shape. Below these is a fluffy layer of down for insulation. The wing and tail feathers are larger and stronger: they are capable of taking the strain of steering the bird and providing the powerful upwards and forwards thrust through the air in flight.

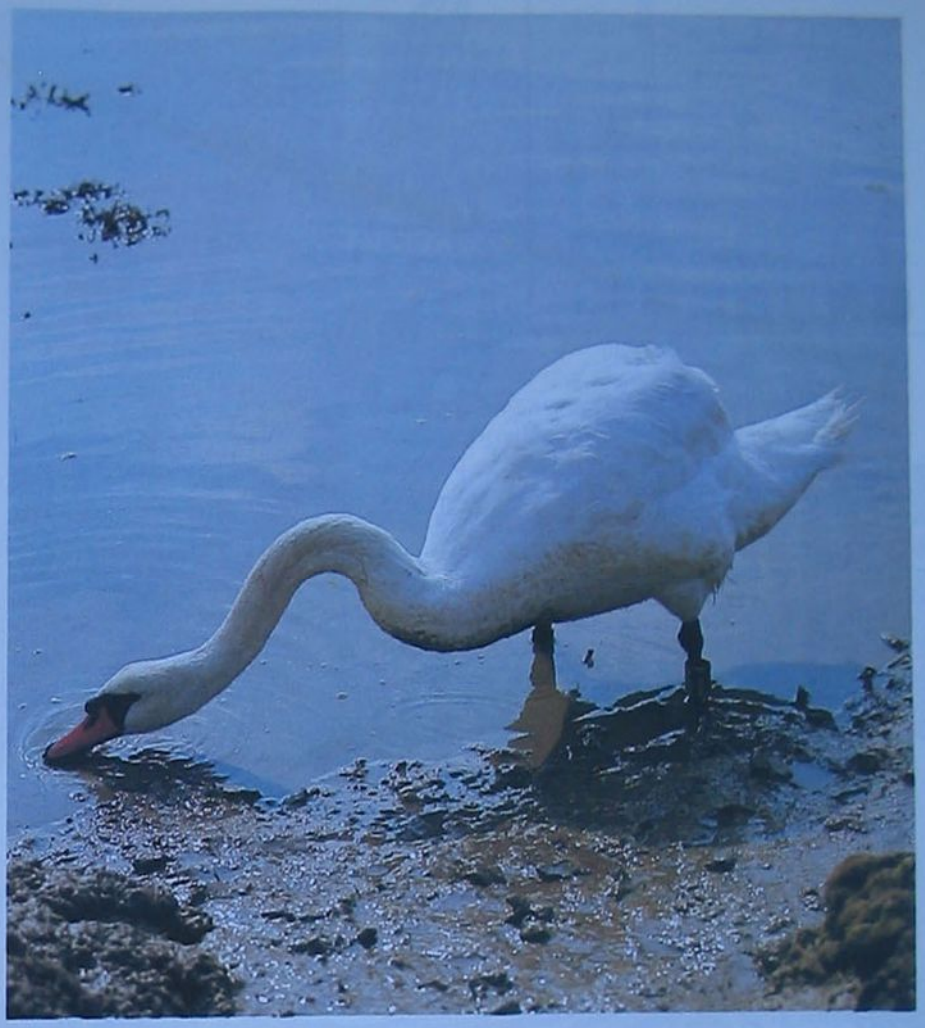
The framework for flight The skeleton of a bird differs markedly from that of a mammal of comparable size or weight. In essence, the bird's skeleton is a rigid box, which protects the vital organs and forms a secure foundation for the attachment of the two pairs of limbs, the head and the tail.

The top of this box is made up of the backbone and two girdles: the pelvic girdle supports the leg joints and the pectoral girdle supports the wings. The girdles are rigid, and the few vertebrae between them are often fused together, so that the whole is a rigid bar.

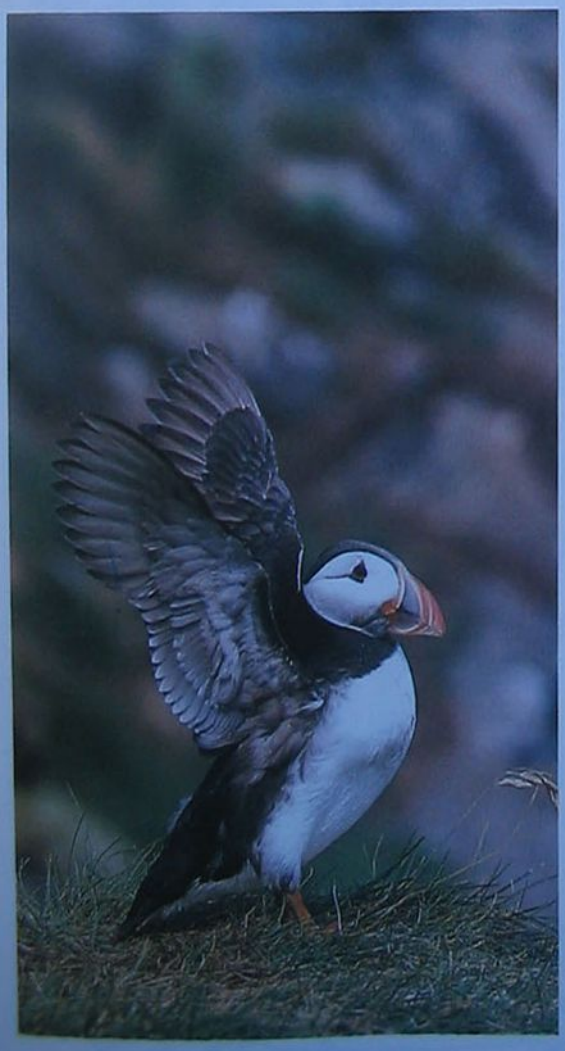
The bottom of the box is the sternum (or breastbone). This is T-shaped in section and runs the full length of the box, adding extra rigidity to the structure. Anyone who has carved a chicken is familiar with this deep-keeled bone, for it is to this that the huge breast muscles (appearing in the cooked bird as white meat) are attached.

Linking these two rigid parts is a series of rib bones, fused to the backbone and sternum, and with backward-pointing prongs called 'uncinate processes', each overlapping the rib behind, further enhancing the strength of the box. Within this structure are safely housed all the vital organs–liver, heart, lungs, stomach and intestines–forming a compact mass. With the wing attachments on the pectoral girdle and the leg attachments on the pelvic girdle so close together, this compact mass conveniently groups the limbs and the centre of gravity of the bird, making the bird's flight more efficient, for little energy is wasted in keeping the whole body in balance.

Looking at the limbs The limb structures of birds in general differ greatly in their relative proportions from those of mammals. The action of flight depends on a great development of some parts of the 'arm', and a reduction in others. Wing beating is performed by the breast muscles: the muscles in the arm (such as the biceps) serve only to adjust the angle of the wing and the feathers so as to control the pattern of flight.



Above: A mute swan drinks, using its flexible neck. One of the more striking differences between birds and mammals is in the structure of the neck. In all mammals, from man to the giraffe, the number of neck vertebrae is constant at seven, and watching a giraffe attempting to drink from ground level shows how much of a constraint this is. Birds, however, have a variable number of neck vertebrae: swans have 25, and house sparrows have 16 and all have more than mammals. In consequence, birds' heads are far more mobile than those of mammals. It seems feasible to argue that the agility this brings in reaching food must go some way towards offsetting the major disadvantage of bird flight–the loss of 'hands' or forepaws as food gathering devices.



Left: A puffin, like other birds of the auk family, has a sturdy 'crush-proof' build that enables it to withstand the pressure of the water as it dives for fish.

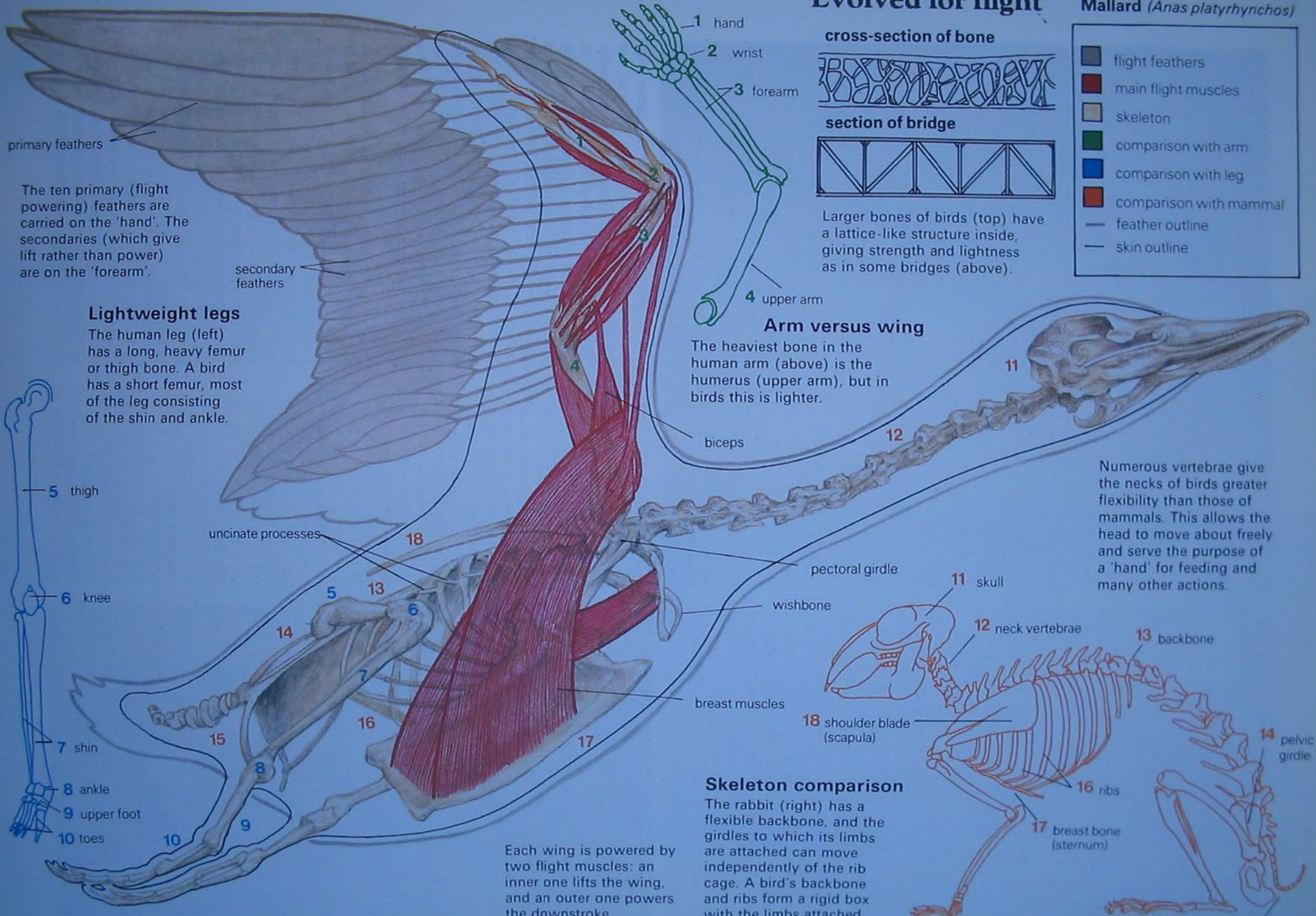
The feathers that provide the thrust necessary for flight (the primary feathers) are carried on a greatly enlarged wrist and hand. The lift necessary for flight is produced by the aerofoil shape of the secondary feathers; these are carried on the radius and ulna–the bones equivalent to those of the human forearm (elbow to wrist). Human arms have a long bone from the shoulder to the elbow–the humerus–which is similar in length to the radius and ulna, and much longer than the wrist and hand. In birds, however, the humerus is relatively short and hardly projects outside the streamlined 'casing' of body feathers.

A similar transformation can be seen in the leg: our long femur (or thigh bone) is short in birds, and rarely visible except on a detailed examination. What looks like the bird's 'knee' (only it faces the wrong way) is in fact its 'ankle', so the visible and often lengthy leg is composed of an upper element–the shin, to which the upper bones of the ankle are fused–and a lower element, between this 'ankle' and the toes. The lower element is formed from the lower ankle bones and the bones of the upper foot.

Lightweight structure Clearly if weight can be saved in a flying creature, there must be a saving in energy, but this cannot be made at the cost of weakening the structure as a whole. In birds there are various solutions to the problems of lightening the skeleton without

Evolved for flight

Mallard *(Anas platyrhynchos)*



The ten primary (flight powering) feathers are carried on the 'hand'. The secondaries (which give lift rather than power) are on the 'forearm'.

Larger bones of birds (top) have a lattice-like structure inside, giving strength and lightness as in some bridges (above).

Lightweight legs

The human leg (left) has a long, heavy femur or thigh bone. A bird has a short femur, most of the leg consisting of the shin and ankle.

Arm versus wing

The heaviest bone in the human arm (above) is the humerus (upper arm), but in birds this is lighter.

Numerous vertebrae give the necks of birds greater flexibility than those of mammals. This allows the head to move about freely and serve the purpose of a 'hand' for feeding and many other actions.

Skeleton comparison

The rabbit (right) has a flexible backbone, and the girdles to which its limbs are attached can move independently of the rib cage. A bird's backbone and ribs form a rigid box with the limbs attached.

Each wing is powered by two flight muscles: an inner one lifts the wing, and an outer one powers the downstroke.

Above: Young barn owls still in their covering of down. This fluffy material is composed of many small feathers that have a thread-like (filamentous) structure. Adult birds of all species usually have an inner layer of down beneath their outer plumage, providing insulation from the cold.

sacrificing strength. Reduction in the size of the humerus and femur, massive bones in many mammals, is one step. But further than that, the birds have evolved bone structures closely similar to those that an engineer would devise if seeking a strong but light-weight shape with which to build, for example, a rigid bridge. Many of the larger bones are tubular or hollow, the central portion (which contributes little to their strength) being reduced to a number of crosswise struts. Thus a section through the length of one of these bones reveals a design closely paralleled in the lattice-like structure on which many bridges are based.

Fast converters Birds generally lead extremely active lives. This high degree of activity makes heavy demands on their physiology. In essence, this means that they need to gather fuel quickly (in the form of food) and convert it equally quickly and efficiently into the energy that powers their muscles.

Like mammals, birds are warm-blooded, but their blood is different in that the red blood corpuscles have nuclei (one of the unusual features of the red corpuscles of mammals is the absence of a nucleus). The system of blood vessels, veins and arteries of birds is, however, broadly similar to that of mammals: the arteries take blood, rich in oxygen and under pressure, to the muscles and organs, while the veins return it, at a lower pressure and having given up much of its oxygen, to the heart.

The high rate of metabolism in birds is facilitated by a fast-beating heart. It is also reflected in many species by a relatively high body temperature. This is particularly true of smaller birds, and measurements have been carried out showing that some species of larks and finches, for example, have a normal body temperature of about 44° C (111° F). This is far higher than the normal temperature of man at 37° C (98.4° F).

One of the truly remarkable features of bird physiology is the highly developed breathing system supplying the bloodstream with a plentiful intake of oxygen. The lungs of mammals are relatively large and are ventilated in a manner similar to the action of a pair of bellows. They are alternately compressed and extended by the upward and downward movement of the diaphragm, a strong muscular membrane above the stomach. Mammalian lungs are never completely emptied during breathing out: in some cases, 20-40% of the air remains inside the lungs. Also, as the lungs are like a closed sack, with only one combined entrance and exit, there is inevitably a cycle of breathing in (when oxygen is extracted) and breathing out.

The respiratory system of birds is vastly different. The lungs themselves are relatively small but they are highly efficient, for they have a large surface area of oxygen-absorbing tissue. Unlike the 'sack-shaped' lungs of mammals, they have a tubular structure, with apertures at either end. One end is connected to the bird's mouth, and the other to a complex system of air sacs which occupies as much as a third or a half of the total body space.

There is no diaphragm – the movements of the massive muscle blocks surrounding the air sacs provide an adequate pumping force. The chambers of the air sacs are so linked that air is drawn in through the lungs (when some oxygen is extracted) before passing to reservoir sacs from which it is directed back to the lungs on a different route on the outward stage of the cycle. Birds are thus able to extract oxygen from a much larger volume of air than mammals of comparable size, and they can do so continuously rather than just during half of the breathing cycle.

Below: Another of the countless different ways in which birds use their feathers is for display in the breeding season, as this handsome teal demonstrates.

THE WILDFOWL OF WEXFORD SLOBS

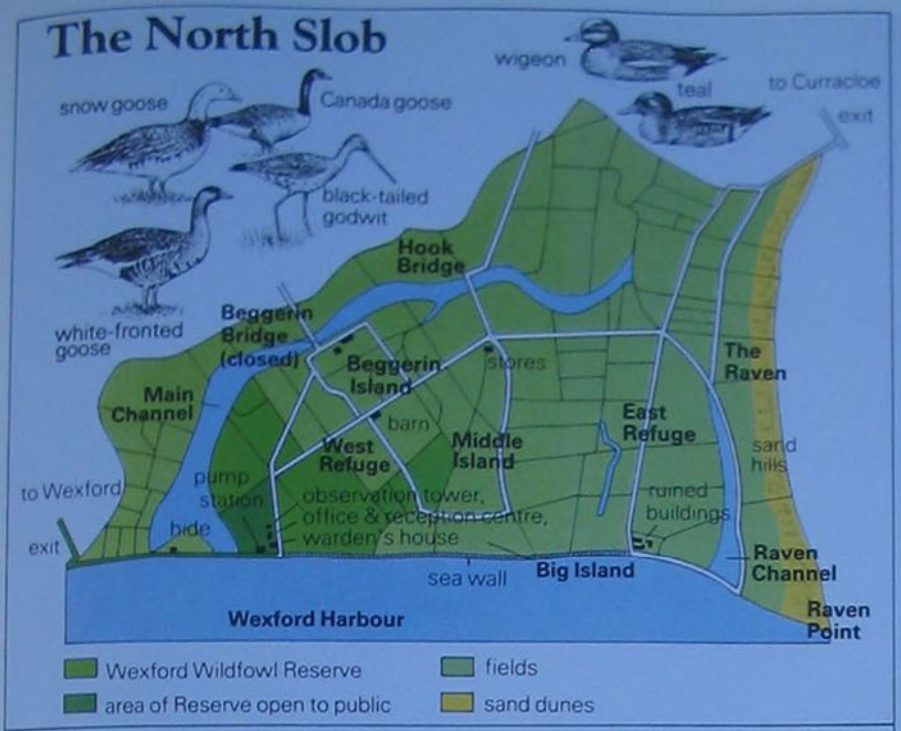
The Wexford Slobs, among the best known of all the ornithological sites in Ireland, have a special attraction for ducks, geese and waders – birds that find secure roosts and rich feeding on the large areas of flat, open farmland in Wexford Harbour.

The 'Slobs' were reclaimed from the extensive shallow areas of sand and mudflats of Wexford Harbour (in south-east Ireland) between the years 1815 and 1849. (Sloblands in Ireland originally meant 'mudflats', but now the name has been revised to include the reclaimed farmland derived from the slobs.)

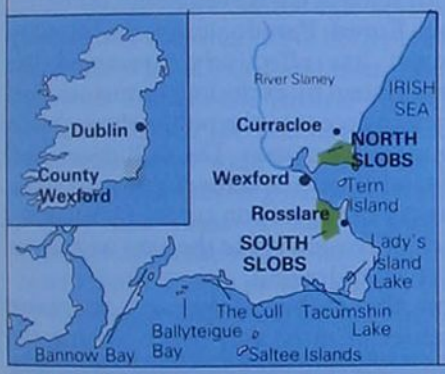
The Slobs consist of two farms of abut 1000 hectares (2500 acres) each, one north and one south of the harbour. On the seaward side they are bordered by extensive sand dunes. Rich mudflats, exposed at low tide, support important populations of wading birds, while mud and sand islands within the harbour provide winter roosts for waders, ducks and geese, together with a few breeding terns in the summer. The sandbanks and spits at the harbour mouth are constantly evolving, most of the sandbanks being remnants of a long sand spit across the southern half of the harbour mouth. When disturbance in the 1960s displaced breeding terns from a major colony at Lady's Island Lake on the south coast of County Wexford, Tern Island in Wexford Harbour quickly became important for the birds. Access to the island was restricted and for the next ten years it was the largest ternery in Ireland, with five breeding tern species, totalling about 2500 pairs. However, Tern Island was mostly washed away in the mid-1970s; some terns have now recolonised Lady's Island Lake once more but

Above: Greenland white-fronted geese on the North Slob. The breeding success of these birds is low and the Irish Government has now introduced a three-year ban on the shooting of whitefronts to allow numbers to increase. At the same time aspects of their conservation are being studied by the Forest and Wildlife Service.

Right: Two birds to watch for on the Slobs – a pale-bellied Brent goose and the rarer lesser yellowlegs.



Wexford Harbour in south-east Ireland belongs to a complex of coastal lagoons and estuaries which includes Lady's Island Lake, Tacumshin Lake, Ballyteigue, The Cull and Bannow Bay.



In a country rich in excellent bird-watching sites, Wexford bird-watchers have an added bonus in their county's geographical location. Migrant wildfowl following both the east and south coasts are concentrated at the headlands and lagoons of the south-east corner of the county. Whitefronted, Canada and snow geese can all be seen on the Slobs, as too can wigeon, teal and black-tailed godwit. The Great Saltee Bird Observatory (situated on the offshore island of the same name) is no longer regularly manned, but rarities are still recorded there each year by enthusiastic birdwatchers.

many are still trying to establish colonies in the harbour nearly ten years later.

Wexford geese The wildfowl of Wexford Harbour have been famous for centuries and the added attraction of the reclaimed slob-lands soon drew geese to the area. Bean geese were reputedly the first to arrive, soon after reclamation. Although some ornithologists suggest that they might have been mistaken for immature Greenland whitefronted geese, they would certainly not have been confused with the adult birds. Subsequent history is more certain. Greylag geese were common from 1900 until the mid 1940s. Their simultaneous decline on the Slobs and in the rest of the country coincided with a substantial increase in the farming of root crops in Scotland, where the Irish population of greylags is thought to have stopped over. Greenland whitefronted geese started to winter on the Slobs in the 1920s. Since their numbers increased during a period when Irish agriculture was poor, it seems likely that these geese were displaced from within Ireland by loss of habitat. Recently, ringing recoveries have shown birds from Wexford and Scotland to have a common breeding range, quite distinct from the geese that winter in the Midlands and west of Ireland. So it seems that the Wexford whitefronts originally came from Scotland.

Roost requirements for wildfowl are less stringent than those for breeding terns and the fortunes of the winter flocks of duck and geese are linked instead to the changes in agriculture on the Slobs. Subsoil drainage carried out on the farmland in the 1960s was seen as a threat to their continued existence in the area and the State and the Irish Wildbird Conservancy jointly acquired 100 hectares (250 acres) of the North Slob as a Wildfowl Reserve. Fears that the wildfowl were in decline proved groundless, however, and numbers have remained fairly constant since regular counting started in the late 1960s. (Between 5000 and 6000 Greenland whitefronts winter on the Slobs each year – half the entire world population of this subspecies; the Wexford Slobs are, therefore, of international importance.) The geese very soon learned to exploit the large areas of stubble and root crops, and Bewick's swans started wintering on the Slobs in increasing numbers. Today the farming emphasis is shifting back to pasture because of the physical constraints dictated by poor-draining soils. The decline in root crops has been paralleled by a drop in Bewick swan numbers and, while the Greenland whitefront numbers did not decline, their competitive use of winter grass has brought them into conflict with local farmers.

This is not the only problem faced by the Greenland whitefronts, however. Juvenile whitefronts of all races can be distinguished from adults in the field by their lack of black belly bars and, at least in the early part of winter, by the absence of a white forehead. The proportion of juveniles in the flocks when they come back from Greenland each summer is very low – on average only 13%. This figure is much lower than for the European and American whitefronts. The Greenland geese have slightly larger broods, thus the proportion of adults that are successful breeders

Below: The attractive dewberry flourishes on the sand dunes at Ballyteigue. You can tell the fruits of the dewberry from those of the blackberry because they have fewer segments and a bluish waxy bloom.

is even lower than for the other subspecies. No-one knows whether the reason for the birds' low productivity lies on the wintering grounds or in Greenland, but the Greenland barnacle goose, which winters in the west of Ireland, has an even poorer breeding record. Both are thought to be unique among migratory geese in lacking staging posts between winter and summer quarters. These stages or breaks in migration are known to be important for other goose species, which time their journey northwards to coincide with the flush of spring grass so important in accumulating fat reserves for the breeding season.

Other bird species The Wexford sloblands are best known for their whitefronted geese and other species often tend to get overlooked. Particularly striking on the Slobs are large numbers of other flocking species–starlings, lapwings, golden plover, curlew, wigeon, rooks, gulls and pigeons. At times, especially in the early part of the winter, the Slobs seem alive with birds–plovers wheeling on silvery wings, noisy flocking starlings cartwheeling over each other as the group moves forward, great flocks of wigeon and mallard, raucous rooks, black-headed gulls and geese, and whitefronts wherever you look.

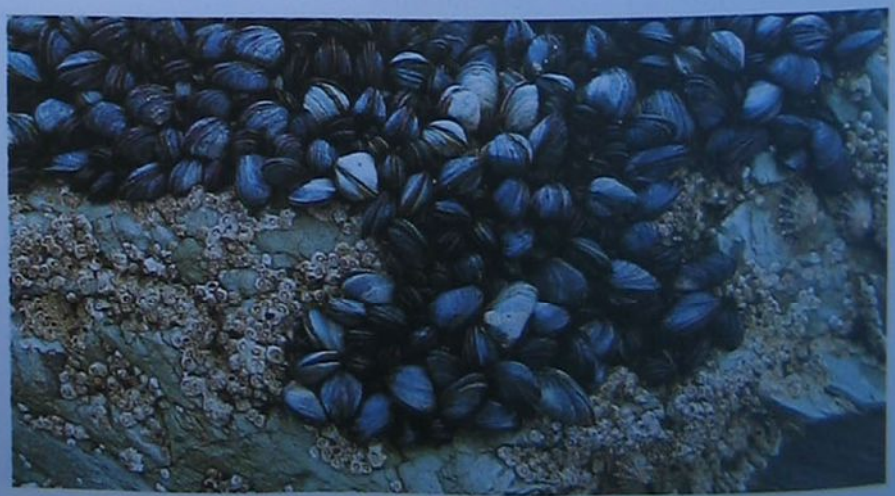
Up to 60,000 waders are estimated to use Wexford Harbour, mainly lapwings, golden plover, curlew, black-tailed godwit and dunlin. Consequently, a number of species of birds of prey are also found in the area. Hen harrier, sparrowhawk, kestrel, peregrine and merlin can all be seen almost daily, and a walk along the seawalls or dykes of the sloblands often reveals the plucked remains of a large number of victims.

The plants of the Slobs Both Slobs are protected from the sea by long stretches of sand dunes. Between Rosslare and the South Slob the dunes have largely been spoiled by suburban housing developments, but to the north of the Harbour, for four miles from south Curracloe to the Raven Point, the dunes are a State Forest. Paradoxically, the Forestry Department has effectively conserved the sand dune system by excluding farmstock and by restricting access to the public through the use of one northern gate. The well-developed series of sand dunes and dune slacks provides a great variety of vegetation types. This variety and a lack of erosion make the area unique on the east coast of Ireland.

Behind the mobile dunes are extensive communities of moss and lichen among the grasslands. These springy carpets have been modified very little by trampling and are probably maintained free from scrub by rabbit grazing. The dune slacks, characterised by shrub willow species, support several plant species rare in Ireland–including round-leaved wintergreen and yellow bird's-nest. Up to 20 years ago the dune slacks were flooded

Above: A view of part of the North Slob in winter. Wexford Harbour, and all the other places referred to here, are within 15 miles of the port of Rosslare, which can be reached from Britain and the Continent by regular ferry services.

Below: A colony of common mussels (you can also see a few barnacles and limpets). Local boats fish Wexford Harbour and the coastal waters for mussels, which support a thriving local industry. Large flocks of scoter feed on these shellfish in the winter months.



each winter but the plantations and improved drainage on the Slobs have caused a lowering of the water table. No indigenous woodland exists here and the plantations are principally of Corsican pine. Although several of the botanically rich areas have been planted, most of the trees have failed and thus little damage has been done to the natural vegetation. On the other hand, the conifers are thought to have minimised wind erosion of the mobile dunes where trampling has had an effect.

Sand and coast A superb sandy beach stretches down the strip of land (bordering the North Slob) known as The Raven. Unmarred by wooden groynes, the tip is a rare example of a dynamic sand/shingle spit, unmanaged by man. The islands and lagoons of The Raven change dramatically throughout the winter. Here, the Greenland whitefronts have one of their two major night-time roosts. In summer ringed plover and little terns make abortive attempts to nest, disturbed only by those visitors energetic enough to make the four-mile trek from the car park. Sandwich terns have recently shown interest in nesting on the outermost spit, but it is washed by the highest tides, so no nest can be permanent.

Wexford Harbour is one of a complex of coastal lagoons and estuaries in south County Wexford–a complex which includes Lady's Island Lake, Tacumshin, Ballyteigue and Bannow Bay. The reclaimed portion of the estuary behind Ballyteigue, known as the Cull, and Tacumshin support many of the winter grassland bird flocks characteristic of the Slobs. Bewick's swans now use the Cull in preference to the Slobs and Greenland whitefronts are also found there occasionally. Lady's Island, Tacumshin and Ballyteigue were all once shallow tidal estuaries which have become blocked off from the sea by shingle and sand bars. All are now brackish water lagoons. There are extensive sand dunes on the landward side of the spits and the rare cottonweed is found on the shingle at Lady's Island Lake. The sand dunes at Ballyteigue possess a rich fauna and flora, including wild asparagus and dewberry.

All three lagoons harbour wintering wildfowl, particularly during the weeks when shooting disturbance is minimal. Both Lady's Island and Tacumshin attract a variety of waders and a surprising number of North American waders of several species are now seen almost annually. There are records of sightings of Baird's, buff-breasted and pectoral sandpipers, dowitchers and lesser yellowlegs. The mudflats and saltmarshes of Bannow Bay support large numbers of the usual wintering wildfowl and waders, including a flock of Brent geese. In terms of numbers of birds, the Bay is second in importance to Wexford Harbour and is well worth a visit since the countryside here retains a wild and rugged character.

Above: Bewick's swans busy feeding on the North Slob.

Below left: Round-leaved wintergreen is one of the rarer plants to be seen on the dune slacks at Wexford.

Below right: A wide range of characteristic insects is present on the strip of land known as The Raven (see map). Among the butterflies found there are the grayling (shown here), the wood white and the gatekeeper. In common with some other species in Ireland, these butterflies are restricted to coastal areas, although they are found in a wider range of habitats in Britain. On the strandline of the undisturbed beaches you may also find two rare arthropods–a beetle and a woodlouse.

THE VARIED LIVES OF GASTROPODS

Not all marine gastropods live their lives sedately grazing on seaweeds, safe within the protection of their hard shells. Many have forsaken this ancestral life-style for a variety of other ways of life, some of them rather surprising.

The familiar garden slugs and snails are examples of gastropod molluscs, the most successful of all mollusc classes with nearly 40,000 species making up 80% of living molluscs. However, land-living slugs and snails represent only a small part of the impressively diverse array found within the class.

In common with all other molluscs, gastropods originated in the sea. The earliest gastropods were shelled creatures which first appeared in the Palaeozoic era, and crawled along on submerged rocks, scraping up encrusting plant life. Of the gastropods living today, winkles, topshells and limpets still feed in the fashion of their ancestors, scraping small particles of seaweed from the rocks to which they are attached. Other gastropods found on or near British coasts have adapted this life-style to varying extents. Here we look at several of the more spectacular species, giving a glimpse of a successful pattern of diversification.

Carnivorous whelks Dogwhelks are found on the seashore together with their grazing relatives, but they have changed their method of feeding to that of predatory carnivores. Dogwhelks prey upon mussels and barnacles on rocky shores, and often appear to hunt in packs, for they feed together in large numbers. Plant-eating gastropods use a toothed ribbon called a radula to scrape up their plant food; carnivorous whelks have adapted this same radula to bore into their prey. The teeth on the radula are reduced in number and strengthened, and the radula is situated together with the mouth on the end of a proboscis. In addition, the front of the dogwhelk's foot contains a gland that secretes acid, which assists the radula in boring through the calcium carbonate shell of its prey.

Dogwhelks are the size of large winkles, but unlike winkles they have an extra 'tube' or canal alongside the main coil of the shell. This houses the inhalant siphon, which sucks seawater in and carries it to the gills. The shell is thick, protecting the dogwhelk from the battering of waves, for mussels and barnacles (on which the dogwhelks feed) are particularly common on wave-exposed shores. If a dogwhelk is washed away down to the lower shore, it attempts to make its way back up the shore, but it may starve to death before it is able to complete its journey.

Slipper limpets This is another group of seashore gastropods with a modified method of feeding: they use their gills to filter food from the surrounding seawater in the same way as does a bivalve such as a mussel or an oyster. As in many bivalves, the gill of a slipper limpet is greatly expanded and covered in little hairs which beat to produce a powerful current. Suspended food particles are trapped in mucus produced from the base of the gill, and are then transferred to the mouth for ingestion.

Above: Sea slugs are opisthobranchs in which the shell is completely absent. This one is *Chromodoris*, a member of the dorid group. Unlike the species which defend themselves with stinging cells from the hydroids on which they feed, dorids tend to rely mainly on camouflage coloration to deter predatory attacks.

Right: A mass of slipper limpets exposed at low tide. They grow on top of one another, as new ones join the chain.

Left: Four dogwhelks on the surface of a rock. When a dogwhelk finds a bivalve such as a mussel, it attaches itself to the shell. It drills with its rasping tongue (radula) for about one minute, then applies its acid secreting gland for 30 to 40 minutes before using the radula again. It takes over eight hours to drill through 2mm of shell, and the shell of a mussel may need two days' work before breakthrough to the soft tissues beneath.

Slipper limpets also have a very unusual growth form: they are often found piled on top of each other. Like most marine molluscs, they hatch from the egg as a swimming larva which settles on hard substrates; the shell of an adult limpet is particularly attractive to the settling larvae.

The developing adult is initially a male, but as it grows it changes into a female. Further larvae settle and eventually a pile of slipper limpets is formed, with large females at the base and a small male at the top. This small male is able to fertilise the females below, and these lay egg capsules attached to the rock or to any slipper limpet shell available nearby.

Introducing opisthobranchs Another group

Spectacular marine gastropods

Dog whelks have shells reaching a size of 2.5cm (1in), usually ash-grey to cream, sometimes marked with brown spiral lines. They are carnivores, drilling into mussel shells or prising open barnacles to gain access to the flesh inside.

Dog whelk
(Nucella lapillus)

The **slipper limpet's** shell has not undergone reduction. It feeds by filtering plankton through its gills. From man's point of view this animal's numerical success causes it to be a pest, for it competes with, and smothers, oysters.

Slipper limpet
(Crepidula fornicata)

Scaphander lignarius is an opisthobranch with a reduced shell about half as long as its body. The body is unable to withdraw into its shell. The prominent burrowing foot is shown here. This large species may reach a length of 14cm (5½in).

Scaphander lignarius

Akera bullata is an opisthobranch with large flapping lobes that enable it to swim. When the animal is at rest (as shown) the lobes (parapodia) are folded round the shell. The shell is coiled and grows to 4cm (1½in) in length.

Akera bullata

The **sea slug** *Limacia clavigera* grows to no more than 2.5cm (1in) long. Lacking a shell, it relies mainly on chemical defence, being unpalatable to fishes and other carnivores. It advertises its distastefulness by its vivid colouring.

Sea slug
Limacia clavigera

The **violet sea snail** has a shell of up to 2.5cm (1in) across. It blows bubbles in a secretion of mucus, forming a raft with which it floats in the surface waters of the Atlantic. The snail attaches its eggs to the underside of the raft.

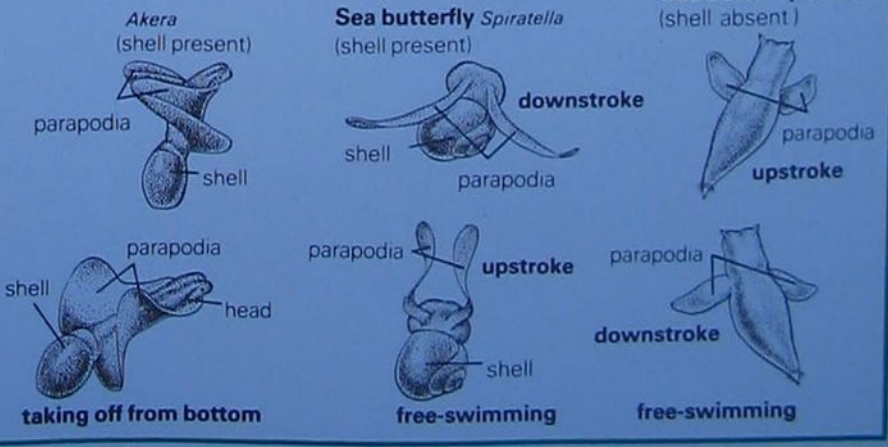
Violet sea snail
(Janthina janthina)

Methods of swimming

Akera bullata dwells on the sea-bed and swims only at certain times of its life, for example in panic. The foot lobes ('wings' or parapodia) are gracefully but vigorously moved up and down.

The tiny shelled sea butterfly *Spiratella* floats with its shell aperture uppermost, and moves its parapodia back and forth in the water like oars.

A faster and more accurate swimmer is the naked sea butterfly *Clione*. Its small parapodia have a highly co-ordinated twisting action, in which both upward and downward strokes propel it forwards. It catches and eats shelled sea butterflies.



of marine gastropods became adapted for burrowing in sediments at the bottom of the sea. A bulky shell is a hindrance to the burrowing process, and in the course of evolution it has been reduced to size. While the shell became smaller, the main burrowing organ, the foot, was expanded, not only to increase burrowing power but also to support the weight of the gastropod in soft mud (on very much the same principle as that of a snowshoe).

This line of evolution led to a group known as the opisthobranchs. One remarkable feature of the group is that it includes gastropods which have evolved the ability to swim. The foot developed extensive lobes that could be flapped to propel the animal up into the water. Initially, perhaps, this was a response to an attack by a predator, such as a starfish. One example of a swimming opisthobranch is *Akera*; it can swim in short bursts.

Other opisthobranchs have evolved which are able to spend the whole of their lives away from the sea bottom. These swimmers are aptly named sea butterflies, and are divided into two groups. The first, *Spiratella* for example, are small–typically only a few millimetres in length–and possess a rudimentary shell. They swim and float in the plankton, feeding on microscopic plants. Members of the second group lack shells altogether, and are generally larger. *Clione* is one such naked sea butterfly, growing to a length of a few centimetres. The naked sea butterflies are carnivores, and their main prey are the shelled sea butterflies, which they crunch and eat with their tough jaws.

Above: The slipper limpet is so called because a large internal shelf makes the empty shell, when seen on the beach, look like a delicate slipper.

Above right: *Natica catena*, a necklace shell, is a gastropod with a reduced shell and an enlarged foot. It is a predator, inhabiting the sand and feeding on bivalves.

Below: The violet sea snail, *Janthina*. Beneath its raft of bubbles you can see the foot, spread out like a sucker as the snail grips the glass of its tank. On the right it stretches out its head to attach its mouth to a by-the-wind sailor (*Velella*), which is its chief prey.

Stings and bright colours The sea slugs represent yet another branch on the tree of evolution. Sea slugs lack the protection of a shell and may rely on chemical defence, producing distasteful secretions associated with bright warning coloration to discourage attacks by other animals. Some sea slugs, however, have more surprising methods of defence. The eolid sea slugs, in particular, store stinging cells from the hydroids on which they feed. The cells accumulate at the tips of protuberances known as cerata, and repel any predator that begins to attack the sea slug. Other species of sea slugs avoid predation by means of camouflage coloration. The variety of colours of sea slugs has the incidental effect of making them attractive and startling finds for naturalists.

Hanging from a raft Sea butterflies are by no means the only gastropods to live away from the sea bottom. *Janthina* is a remarkable violet snail that lives at the surface of the sea. It hangs from a float which it makes itself. The float is a raft of air bubbles surrounded by mucus: each mucus-covered bubble takes about one minute to secrete.

The purple or violet coloration of *Janthina* is typical of many organisms living at the surface of the sea, and may be an adaptation against aerial attack from seabirds, providing *Janthina* with camouflage to blend in with the deep blue of the sea below. Although they are inhabitants of the open sea, *Janthina* individuals or their beautiful shells are often washed up on to the south-west shores of Britain and Ireland (particularly after a period of south-west winds).

MAGNOLIAS AND TULIP TREES

Arguably, no other tree grown in Britain bears such spectacularly beautiful flowers as the magnolia and its less well-known relative, the tulip tree. Yet these same flowers have one of the most primitive structures of any in the world.

Above: The magnolia that has been cultivated the longest is probably the yulan tree (*Magnolia denudata*), which has been grown in the gardens of its native China since the Tang Dynasty (618-907). The Chinese used the buds for medicinal and culinary purposes but in Britain, where it was introduced around 1790, it is grown purely as an ornamental. A deciduous tree growing to a height of 18m (60ft), it bears copious white flowers before the leaves open.

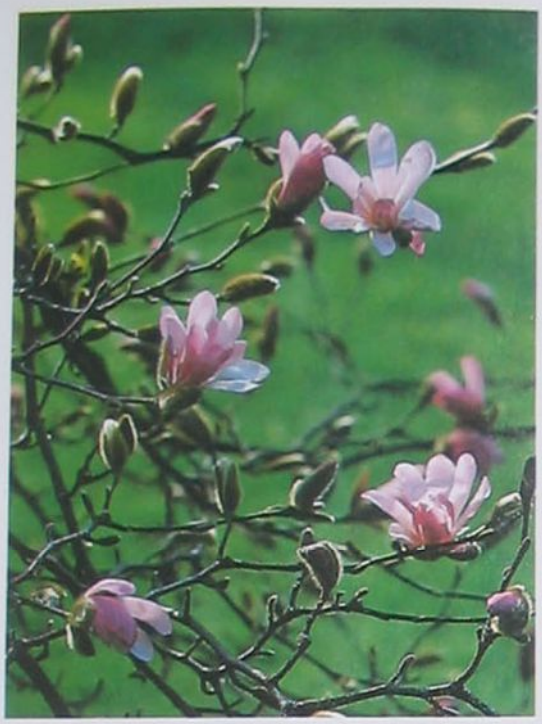
Magnolias and tulip trees both belong to the same family, the magnolia family or Magnoliaceae, a group generally considered to be one of the most primitive families of flowering plants. Today, the trees and shrubs of this family are confined to America and south-east Asia, but the fossil record shows that the family was once distributed throughout the whole of Europe and as far north as northern Alaska and Greenland. Fossils of leaves and flowers looking like those of magnolia have been found in rocks 100 million years old, and there can be no doubt that magnolia-like plants were a feature of the landscapes through which dinosaurs roamed.

Magnolia species The genus *Magnolia* is named after Pierre Magnol (1638-1715), who was professor of botany and medicine at Montpellier in France. Of the 80 or so species occurring today, about a third are native to the south-east United States, Mexico, Central America and the northern part of South America. The remainder come from the area bounded by the Himalayas, Japan and Java. More than half the species are tropical but, in spite of most being montane, they do not grow successfully out of doors in Britain. Only those magnolias from temperate latitudes are hardy here.

Evergreen magnolias While the majority of magnolias are deciduous, some of the most impressive are evergreen. One such is *Magnolia grandiflora*, a species introduced to Britain from the southern United States in 1734. In its natural environment it grows to a height of 30m (100ft). In Britain, however, it never develops its full magnificence and is often seen as a small shrub or tree growing against a south-facing wall. It bears creamy-white flowers up to 30cm (1ft) across with purple stamens.

The white laurel (*M. virginiana*) was the first American magnolia introduced to Britain, in 1688. A semi-evergreen species from the eastern United States, it bears rounded creamy-white flowers with a heavy fragrance – in contrast to the lightly scented flowers of *M. grandiflora*.

Another evergreen species from the eastern



Left: Magnolia 'Leonard Messel', one of a great number of cultivated varieties that have been developed for gardens. Like many other deciduous magnolias, 'Leonard Messel' flowers in spring before its leaves unfurl.

Below: The star magnolia (*M. stellata*) from Japan is the earliest of the outdoor magnolias to flower in Britain, its fragrant flowers with 12-18 white tepals appearing in March. A similar-looking species is *M. kobus*. It, too, has white star-shaped flowers but is a larger tree. It was introduced from Japan in 1709.

Left: In many species of magnolias the fruits ripen to a collection of brightly coloured seeds—as in *M. mollicomata*, one of the less familiar species of magnolias in Britain. In all magnolias, the seeds, whether brightly coloured or not, develop a fleshy outer layer after fertilisation. This layer serves to attract birds, which help to disperse the seeds. In tulip trees the seeds are smaller and do not develop such a fleshy outer coat.

United States is the umbrella tree (*M. tripetala*). Introduced in 1752, it too has strongly scented flowers.

Deciduous species Among several deciduous magnolias grown in Britain is the yulan tree (*M. denudata*), a species that has been cultivated in its native China since at least a thousand years ago.

Also from China is *M. liliiflora*, which forms a large bush bearing purplish-white flowers. In 1820 a hybrid was produced from these two deciduous species. Known as *M. × soulangiana*, cultivars from it are widely planted today.

Primitive structure Why do botanists consider magnolias to be so primitive? The answer lies partly in the structure of their flowers and leaves.

When a magnolia flower opens, the enclosing bud scales drop off to reveal single blooms, typically creamy to purplish-white in colour. Although prized for their beauty, these flowers do not possess true petals, nor do they have sepals (the outer green 'floral leaves' found on many other flowers). Instead, the coloration is provided by whorls of structures intermediate in form between petals and sepals, and known as tepals. In some species the tepals in the outermost whorl are reduced and resemble sepals, while those towards the middle are more petal-like. All these features are considered to be primitive.

The whorls of tepals surround the stamens, which in turn surround the carpels—the female part of the flower consisting of an ovary containing the ovules (the unfertilised seeds) and their attendant styles and stigmas. Both the stamens and the carpels are arranged in a conspicuous spiral, another feature considered by botanists to be primitive.

The stamens bear anthers consisting of two pollen sacs, which split open longitudinally to release the pollen grains. The shape of the pollen grains provides another clue to the primitive nature of magnolias. The grains of most other dicotyledons have three pores or furrows in their outer wall, whereas those of magnolias have a single longitudinal furrow along one side. Some of the oldest fossilised pollen grains thought to belong to flowering plants have the same furrow.

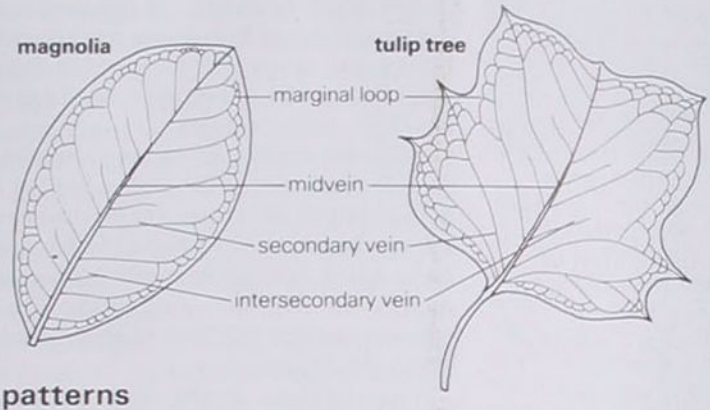
The leaves also share certain features in common with those of primitive flowering plants, particularly in the way that some veins loop round to meet each other near the margins whereas others peter out beforehand. In some species the courses and thicknesses of the veins are highly variable.

Tulip trees Many of the primitive features of magnolias are also found on their close relatives, the tulip trees, genus *Liriodendron*. The more common one in Britain, *L. tulipifera*, was introduced to Europe from its native eastern North America in the 17th century. The other species, *L. chinense*, was discovered in the mountains of central China in 1875. It is a smaller, more compact tree than *L. tulipifera*.

Magnolia fruit

Left: The fruit of both a magnolia (shown here) and a tulip tree is a cone-shaped collection of carpels, which split open when ripe to expose the seeds.

Below: The leaves of a magnolia and a tulip tree show the same primitive pattern of veins. A series of veins, called secondary veins, branch off from the midvein and loop round near the margin to join one another. Some, called intersecondary veins, peter out before the margin.



Vein patterns

Left: A close-up of the cultivar *M. grandiflora* 'Exmouth Variety', clearly shows the structure of a typical magnolia flower. Whorls of white petal-like tepals surround the cream-coloured stamens, which in turn surround the female carpels. Both the stamens and the carpels are arranged in a spiral, a feature regarded by botanists as primitive.

Below left: The flower of a tulip tree has obvious similarities to that of a magnolia, but there are also some important differences. The six greenish structures surrounding the stamens and carpels are petals, not tepals. The orange-white marks at their bases are nectaries. Behind the petals lie three greenish sepals, one of which can be seen here.

Right: The tulip tree *Liriodendron tulipifera* grows well in our climate, reaching a height of 25m (80ft).

The leaves of tulip trees are readily identifiable by their bizarre shape, for their apex consists of two pointed lobes.

The trees flower between May and August, with most blossoms appearing in June and July. While the stamens and carpels resemble those of magnolia flowers, the petals and sepals are better differentiated in *Liriodendron*. The flowers bear a superficial resemblance to tulips – hence the trees' common name – but the two plants are unrelated. Each flower has a whorl of three sepals reflexed (bent back) from the main flower. There are six petals, about 5cm (2in) long, greenish-white outside and yellowish inside.

After fertilisation each carpel forms a winged seed on a short stalk. The fruits are borne in large numbers on a dense, cone-like structure, but in Britain the fruit rarely ripens.

Diverse distribution One further reason for considering the magnolia family to be primitive is the present distribution of its members in two widely separated regions of the world – America and south-east Asia. It is unreasonable to expect that the numerous features characterising these plants evolved independently on both sides of the Pacific Ocean.

Instead, the occurrence of magnolia-like fossils in a great many countries supports the idea that the family was once much more widespread. But, as climates changed and perhaps the tolerances of magnolias and tulip trees to their environments altered, so the distribution shrank and split into two. It may be, therefore, that today's plants are but a remnant of a previously more diverse and possibly more spectacular group.

ANGLER FISHES

One of the most extraordinary looking of fishes, the angler fish is also among the most highly adapted, possessing a 'fishing rod' for luring prey into its capacious jaws.

Above: The angler fish is not often seen moving about on the sea-bed, preferring instead to spend most of its time hiding in wait for prey (below). When it settles down for a period of fishing, an angler fish digs itself into the sand or stones, then raises itself up and flaps down again, spreading out the skin flaps on the sides of its body. As the loose sand and bits of weed dislodged by the digging come to rest on the angler's back the camouflage is complete.

The shallow coastal waters around Britain and Ireland are the home of two species of angler fish; they are even found in estuaries. The commoner of these is *Lophius piscatorius*, known simply as the common angler fish.

This species is a huge fish, growing to a maximum length of 2m (6½ft) and weighing 40kg (90lb). In its general shape it resembles a banjo. The head and body are flattened from above, and the tail tapers gradually to the tail fin. Just behind the head are two large fan-like pectoral fins, and there is a small dorsal fin towards the tail directly above the anal fin. The pelvic fins are tucked away under the belly and look like small legs.

The two most striking features about the angler are the size of its mouth, which occupies the whole width of the head, and the series of long whip-like rays on the head and the front of the back. The rays represent the last vestiges of the first dorsal fin. The foremost of these rays has a leafy double flap at its tip; at the base of the flap there is a small worm-like organ. This is the lure used to entice fishes towards its mouth.

The angler is a master of camouflage and can change the colour of its back perfectly to match any natural background. In contrast to the neutral colouring of the back, the underside is pure white, except for the tips of the pelvic fins, which are black, and the pectoral and anal fins, which are dusky.

A second species It was the characteristic white underside of the angler that led to the discovery, only ten years ago, of a second inshore species of angler fish in British waters. Occasionally an angler with a dusky underside was caught, and a close examination revealed that it differs from the common angler in other ways as well. The new species was subsequently identified as *Lophius budegassa*, a species until then known mainly from the Mediterranean.

Later captures have shown that this species occurs fairly regularly off the southern and western coasts of Britain but it is less common than *L. piscatorius*. Because of the distinctive coloration of its underside it has been named the black-bellied angler.

Different depths As far as is known, both species have similar life-styles, but the black-bellied angler seems to live in deeper water, mainly between 100-300m (55-165 fathoms), although it has occasionally been caught at depths of 50m (27 fathoms). The more common angler fish lives mainly between 18-100m (10-55 fathoms).

The common angler lives on sandy or gravelly sea-beds, or on shell grounds; it is also often found on rocky sea-beds, usually on the edges of reefs or rocks where sand patches offer it a chance to hide. It is, however, very adaptable and is occasionally captured in muddy places such as estuaries.

The angler has a distinctly sedentary life-style, spending most of its time hidden on the

sea-bed. Yet it is occasionally seen to swim, propelling itself with its broad paddle-like tail fin.

Fishing for prey The ability of the angler fish to attract prey to itself by means of a rod and lure is one of the most fascinating aspects of its natural history. As a potential victim approaches, the angler raises its first dorsal fin ray above its back and bends it forwards, sometimes jerking the 'bait' on the rod to and fro to attract the prey. Any fish showing an interest is lured closer. It does not need to come very close, however, for the angler's huge mouth and throat can, when opened, create such an inrush of water that the prey is carried straight inside.

The angler eats virtually any species common in the area where it lives, particularly small fishes easily attracted by its lure.

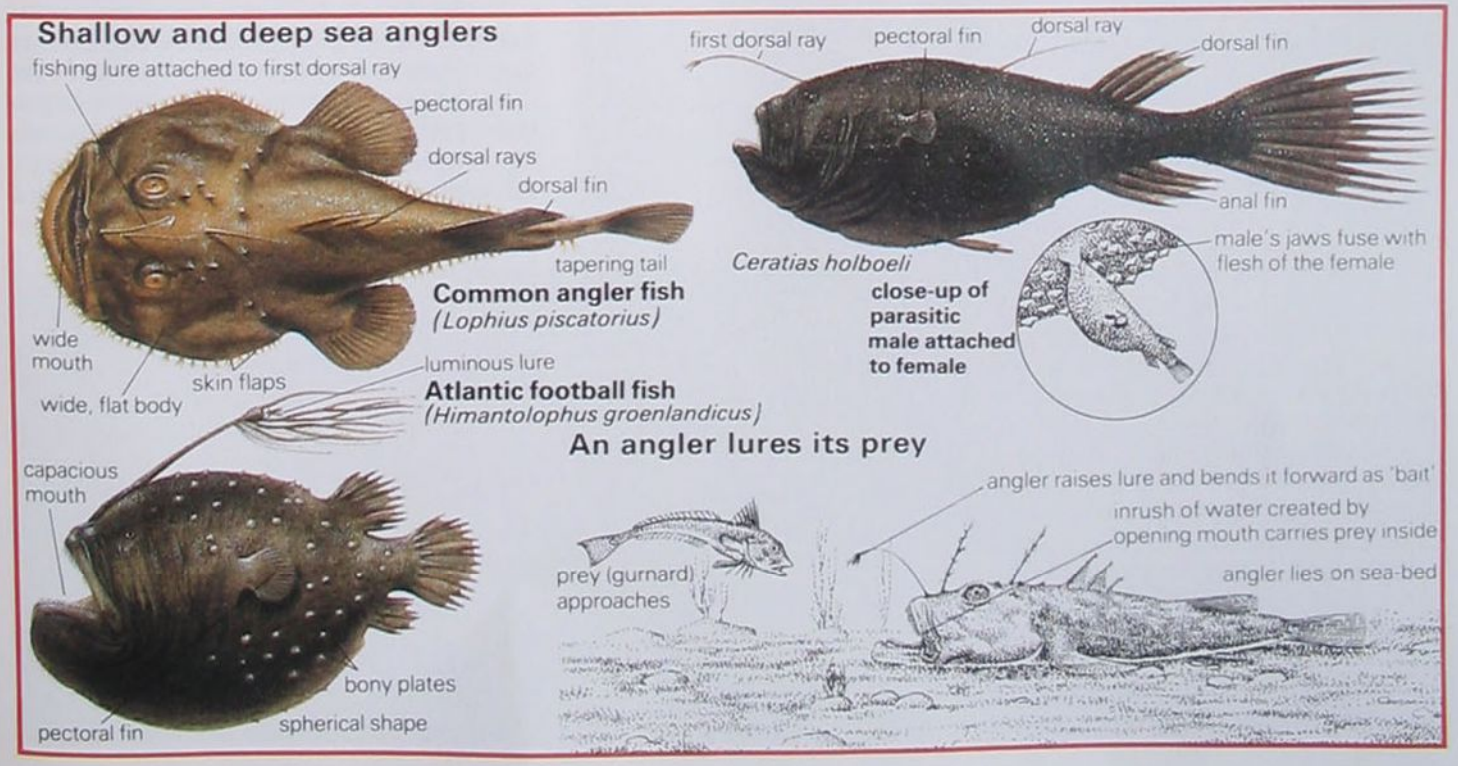
Breeding habits The common angler breeds in spring and early summer in deep water well offshore. The eggs are shed as ribbon-like gelatinous sheets, usually only one egg thick. The young fishes have enormously prolonged fin rays and float near the surface buoyed up by the large surface area of these fins. During this stage they are carried considerable distances by the ocean's currents and may be swept into areas, such as the North Sea, where the adult forms are rare.

Deep-water species There are many other species of angler, rarely seen because they live in deep water. Several have been recorded in the Atlantic Ocean off the British and Irish coasts, one of which is the Atlantic football fish (*Himantolophus groenlandicus*). This species, occasionally caught by trawlers deep-fishing for hake, is almost spherical, and large specimens are the size of a football. It has sparse bony plates on its back and sides, each with a spine in the middle.

Above: The mouth of an angler is equipped with long backward-pointing teeth to prevent any prey escaping. Its diet consists mainly of smaller fishes, such as whiting, young cod and haddock, though the number of crustaceans found in its stomach suggests that, as well as taking fishes, an angler also snaps at anything else passing by.

Below: Angler fishes have a bizarre and somewhat menacing appearance.

Another deep-water species found to the west of the British Isles is *Ceratias holboeli*. These fishes have solved the problem of finding one another at spawning time in the immensity of the deep, dark sea by a device unique among vertebrates—the male, which is never longer than 6cm (2½in), is parasitic upon the much larger (1.2m/4ft) female. Immature males and females are free-swimming but when a male makes contact with a maturing female he takes a firm hold on her skin with his jaws and hangs on for the rest of his life. Eventually, his jaws fuse with the flesh of the female, his gut and gills degenerate, and the female's blood circulation provides him with oxygen and nourishment.



UN-NATURAL SELECTION

For centuries farmers have controlled the mating of their animals to improve their stock. Today new breeds are still being created, such as the British Milksheep.

Above: The Hereford is the most popular beef breed in this country, yet its early history can be traced back to only a few animals, including Silver, an outstanding 18th century cow, and Sir David, a bull. Today bulls are often mated with dairy cows to produce milk and crossbred beef calves.

Below: The primitive Soay sheep of St Kilda are of increasing interest to breeders for their hardy characteristics.

Wild animals evolve through natural selection–the ability of the fittest to survive. The spectacular success of some species–the fox, for example–lies in their ability to adapt to new environments as their traditional habitats are altered or destroyed.

Domestic animals have evolved in an entirely different way. They have been subject to artificial selection by man for the last 10,000 years. The rate of change within a population is determined mainly by the intensity of the selection pressures: as the owners of livestock have understood more clearly the principles of genetics, their selection programmes have become more efficient and their livestock have changed, and often improved, more rapidly.

Early days Ancient records show that deliberate selection of livestock was practised as early as the third millenium BC. In southern Mesopotamia the inventory of an estate near Lagash included a bull which was imported from the upland kingdom of Elam to prevent deterioration of the herd in the sultry climate of the plain.

In the British Isles the opportunities for livestock improvement were limited as long as many types of animals roamed together on the common land. The only method of selection that could be practised was castration. However, as soon as the enclosures took place the movement of animals could be controlled and matings could be planned. The improve-

ment of livestock in the British Isles by deliberate selection thus started effectively in the early 18th century. Records show, for example, that in 1710 a famous breeder, Webster of Canley, purchased two Longhorn cows of the superior Westmorland and Lancashire variety for his farm in Warwickshire.

British breeders The first breeder to be noted nationally as an improver of livestock was Robert Bakewell of Dishley Grange in Leicestershire. His work received wide publicity, but his success rested heavily on the improvements achieved by earlier breeders, such as Webster of Canley. Bakewell started his programme around 1750 with Shire horses, Leicester sheep and Longhorn cattle.

His incentive to improve the Longhorn was the change in market demand with the Industrial Revolution and a growing need for beef animals. The original Longhorn had a thick hide, long horns, long hair, coarse shoulders and heavy bones, and reached maturity very slowly. Bakewell selected animals that approached most closely his hypothetical ideal, and then he mated the best males and females of succeeding generations, so transforming the Longhorn into a smaller, finer-boned animal which had more meat on the valuable hindquarters and which matured earlier. In this process the breed lost much of its hardiness, its milk yield was reduced, and it retained its horns. Long horns became a severe disadvantage when cattle were housed in a confined area, and the Longhorn was eventually superseded by other breeds. Today it is a rare breed.

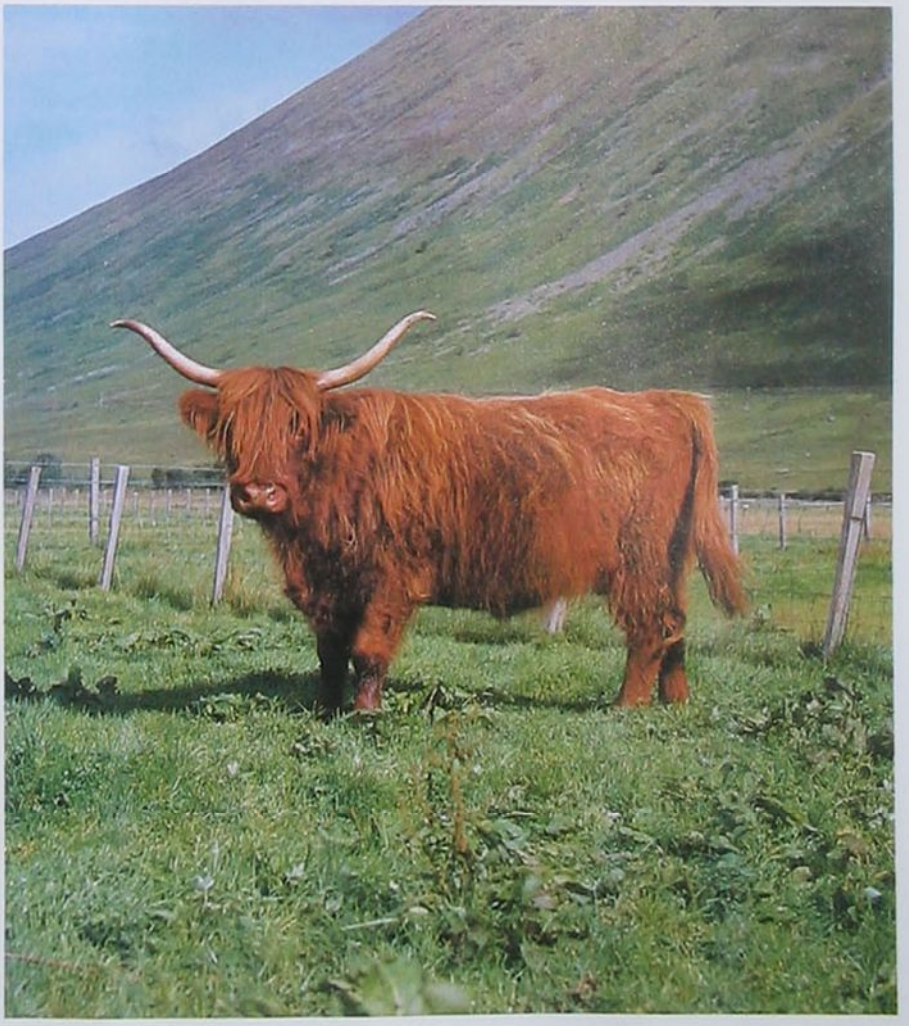
Bakewell's policy of breeding 'best to best' inevitably led him back to the same female families and bull lines within the Longhorn breed. The result was inbreeding–the mating of closely related animals. Inbreeding can be a useful aid to the animal breeder: it can concentrate the qualities of outstanding animals in their descendants, and it usually leads to greater uniformity within a population. On the other hand, it can also lead to reduced vigour and viability, and poor performance, and it is more likely to expose any undesirable recessive characteristics lurking in the genotype of the breed, which may produce deformed animals. However, most successful breeders who were improving their livestock in the 18th and 19th centuries used inbreeding as an integral part of their programmes.

These improvement programmes changed many British cattle from triple-purpose to specialist animals. Previously they had been large, powerful animals used for pulling carts and ploughs, producing milk as a by-product, and meat only when their working life was ended. They became changed into smoother, softer, finer animals, designed for either milk or meat production. The capacious udder or well-fleshed hindquarters were preferred to powerful forequarters.

While the Longhorn is now rare, the Hereford has become the most popular beef breed in the British Isles, although its early history and development were very similar. Members of the Tompkins family were the first noted improvers of the breed in the late 18th century, and their herd was based on an outstanding cow called Silver. In the early 19th century the breed was dominated equally strongly by the Hewer family and their bull, Sir David; the influence of these two families resulted in a high level of inbreeding in Hereford cattle. Bakewell and Tomkins both wanted to change the conformation of their animals, while Hewer's main objective was to establish a standard recognisable colour. The red, white-faced Hereford cattle seen in many

Above: The Longhorn was chosen by Robert Bakewell, the 18th century breeder, for his experiments to produce good beef animals. He selected and mated the best males and females of succeeding generations, and rapidly transformed the Longhorn into a smaller, fine-boned animal.

Below: The hardy Highland retains many of its primitive characteristics. Today it is crossed with Beef Shorthorn bulls to produce the Luing.



Above: A Suffolk ewe and her lamb. The Suffolk was originally developed in East Anglia in the late 18th Century but it is now common in many habitats and has successfully been exported all over the world. It grows fast and produces good meat.

pastures today both in the British Isles and throughout the world confirm his success.

Perhaps the most successful breeders of that era were the Collings brothers, Charles and Robert of Darlington in County Durham. They used to extremes the application of inbreeding in livestock improvement. They wanted more productive cattle, and they selected for medium size, early maturity, flesh production, utility and beauty of form. They carefully identified the outstanding animals and mated their descendants closely. The famous 'Durham Ox' and the 'White Heifer that Travelled' were both exhibited around the country and attracted great interest in their work.

Sheep The Norfolk Horn sheep originally inhabited the exposed, infertile Breckland of East Anglia. It was noted for its hardiness, robustness, freedom from disease, long legs and activity, and the ewes were prolific and good mothers. It was not a very productive breed, but it lived where other breeds would have died. As land was enclosed and improved, the Norfolk Horn's hardiness and thriftiness became less important, and its mobility and independence became a disadvantage. The breed did not possess the genes necessary to enable it to adapt to the new conditions, but around 1800 it was crossed with Southdown rams which imparted qualities of early maturity, compactness of form and a more placid temperament. Eventually the fusion of these two breeds led to an entirely new breed, the Suffolk, which today is one of the most popular international breeds of sheep. It has retained the lean-ness and some of the prolificacy of the Norfolk Horn, but added to it the earlier maturity and better shape of the Southdown.

The future Each breeder has his own aims, and the success of his programme depends on three factors: the validity of his original

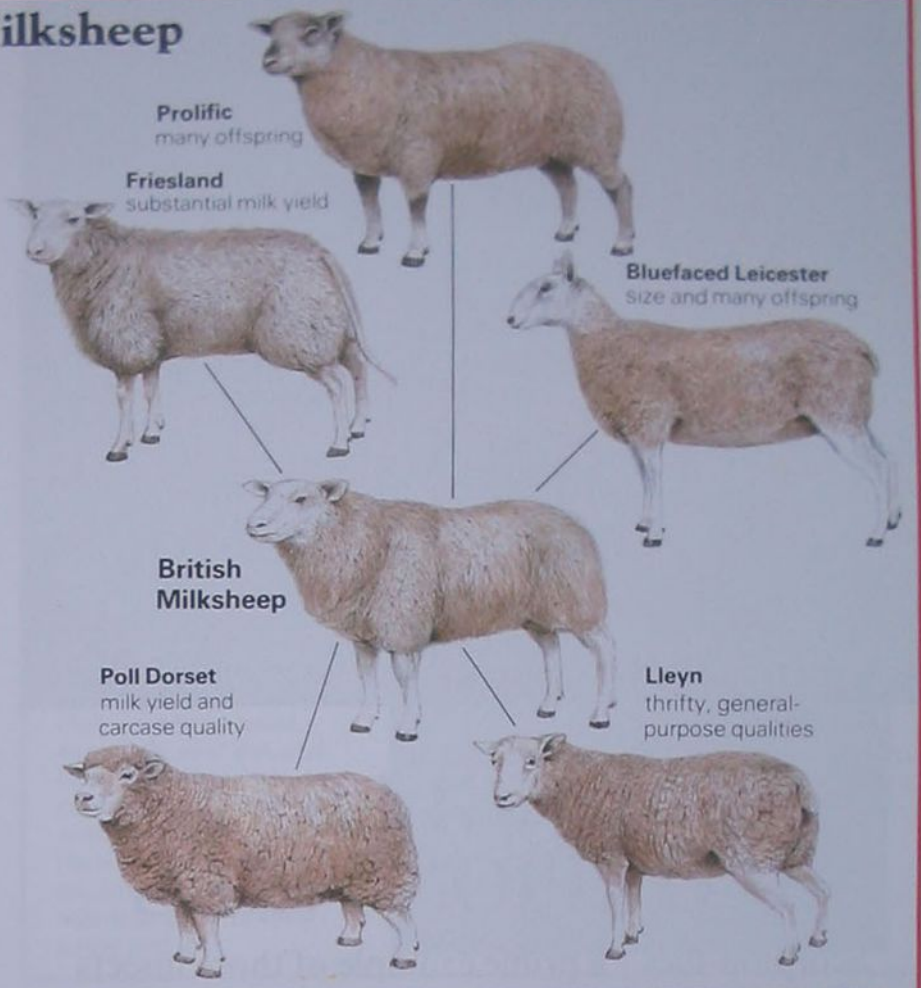
A new breed: British Milksheep

The author wanted to create a new, profitable, high performance breed of sheep. He evaluated the potential source of genetic material, both in terms of breed and individual animals. Five breeds were selected after trials. He already owned high performance animals of the Prolific, Bluefaced Leicester and Poll Dorset breeds, and he scrutinised the records of the other two to find superior animals, which he then purchased.

The next task was to blend together the animals from these five breeds into a new combination of genes from which the new British Milksheep was eventually created. At each generation the best animals were selected for their ability to produce large numbers of lambs and to yield the milk necessary to rear them. Because of this, the British Milksheep is superior to any of its parent breeds. The total programme took 15 years.

The final problem is to maintain the qualities and superiority of the breed. This is achieved by dividing the breed into families. Within each family the best animals are used in inbreeding programmes to concentrate the superior qualities. The other animals are used in a cyclic crossing system whereby the females in the first family are mated to males in the second family, and females in the second family are mated to males in the third, and so on, to keep inbreeding within the total population to a low level.

The British Milksheep (right) produces an average of three lambs per crop, compared with the average of 1½ lambs for other breeds, and it yields up to a gallon (3.7 litres) of milk daily, compared with an average of less than half a gallon for the other British breeds. It enables lowland sheep enterprises to achieve levels of profitability equal to, or better than, those of other livestock enterprises.



Left: White Park cattle, distinctive and attractive animals, are known for their qualities of longevity, disease resistance, strong maternal instincts and lean carcases. They have been the least affected of our cattle by artificial selection, and they thrive on less rich food than high production breeds. In the last ten years the herds have doubled from five to ten, but White Park cattle are still a rare breed.

objectives, the correctness of the matings and the efficiency of his selection procedures. The lessons learned by the earlier successful breeders of livestock were employed by the author to create a new breed of sheep–the British Milksheep.

Successful breeding in the future will depend largely on breeders being able to maintain the recognisable characteristics of individual breeds, such as their colour, shape, flesh production and so on; at the same time it is important to ensure that there is a sufficiently varied pool of genes available to draw on as the environment, fashions and requirements change. Each breed is suited to specific circumstances and farming systems.

Once more the hardy qualities of some of the ancient breeds (for example, the North Ronaldsay or Soay sheep, or the White Park cattle) are being appreciated by those farmers who are looking for animals that are independent and easy to manage in upland areas. Great efforts are now being made to see that they and other minor breeds in this country do not become extinct. At the same time, farmers with lush, lowland pastures are looking for breeds with high output and high turnover, such as the new British Milksheep, which make efficient use of the land and so enable food to be produced more cheaply than when less productive breeds are used. There is always more research to be done.

STINGLESS SCORPION-FLIES

Scorpion-flies– a prime example of those insects whose names give rise to unfounded fears– are in fact totally harmless, their everyday name deriving from the male's curious up-curving genital capsule, which vaguely resembles a scorpion's sting.

Only four species of scorpion-fly (order Mecoptera) occur in Britain, three of them belonging to the genus *Panorpa*, and the fourth, the snow flea, to the genus *Boreus*. All three *Panorpa* species are equally common, sharing much the same distribution, habitat and habits. They appear as adults from May to August, being found along dense hedgerows, thickets, nettle-beds and in open woods, especially in damp, somewhat shady areas, where they can be seen flying sluggishly in search of food and mates.

Above: Scorpion-flies are easy to spot with their long, transparent wings speckled with black or dark brown. Omnivorous feeders, they are partial to dead insects. The one shown below is eating a moth caught in a spider's web.

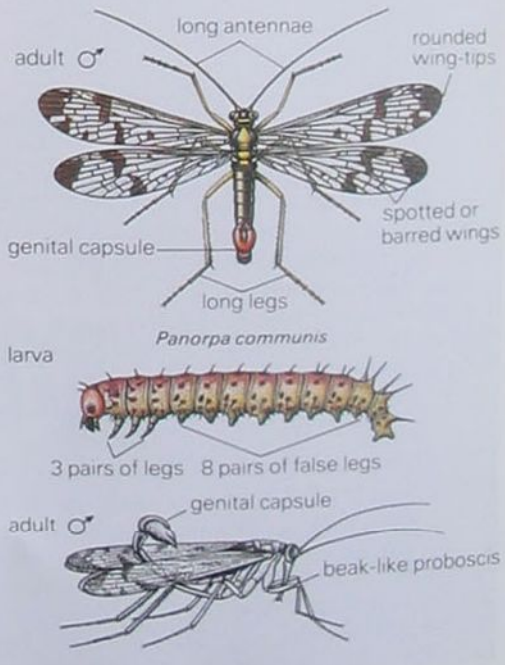
Scorpion-fly features Each *Panorpa* species is 2cm ($\frac{3}{4}$in) long with a wingspan of 3cm (1in), the dusky transparent wings being variably spotted or barred with black or dark brown and rounded at the tips. At rest the wings are folded flat in a characteristic triangle exposing the abdomen. Both sexes have a pale yellow thorax and a yellow abdomen banded with black. Their legs are long, as are their thread-like antennae.

The male is distinguished from the female by the glossy orange-red enlargement of his abdomen which, while looking superficially similar to a scorpion's sting, is merely a genital capsule armed with forceps for clinging to the female during mating. This feature apart, both sexes have a most distinctive facial appearance, the front part of the head being lengthened and tapered downwards to form a beak-like proboscis, at the end of which are small toothed mandibles for biting and chewing, together with short palps for handling and tasting food.

Vision is probably relatively acute since the scorpion-fly's shiny, dark brown compound eyes are large and protruding. There are also three simple eyes arranged in a triangle between the compound eyes and the antennae. As in all insects, the simple eyes play little part in vision, but act as light intensity perceptors.

Look-alikes Distinguishing the three British *Panorpa* species is not easy. The markings on the wings of *Panorpa communis*, probably the most frequently seen species, tend to be rather larger than those of the very similar *Panorpa germanica* and *Panorpa cognata*. *P. germanica*'s wings are more distinctly spotted,

Recognising a scorpion-fly



while *P. cognata* has smaller and fewer markings. Such coloration is, however, an unreliable guide to identification since there is much variation within each species.

They are more reliably identified by reference to the arrangement of their wing veins, the shape and size of the female's abdominal segments, and the detailed structure of the male's hind abdomen and genital capsule.

While all three species can be seen on the wing at roughly the same time, *Panorpa cognata* tends to emerge when the other two species are dying off.

Diverse feeders Scorpion-flies are, to a large extent, omnivorous. Their tapered rostrum or beak, armed with small cutting mandibles at the tip, allows them to feed on smaller, less mobile insects such as aphids, and they are known to eat dead insects of many kinds. They also suck up plant nectar and honeydew, and pierce and suck fruits. Some scorpion-flies have even been observed feeding on bird-droppings.

Digestion is probably partly external, salivary juices being inserted into more solid food to liquefy it and so allow it to be sucked up more easily. The soil-dwelling scorpion-fly larvae enjoy a similarly varied diet and feeding method.

The male's dangerous duty A particularly strange item of food is enjoyed by the female scorpion-fly prior to and during mating. The male, foreseeing the dangers involved in mating (his partner is likely to attack and kill him), releases rapidly hardening saliva on to a leaf near the female. She eats this sticky substance while he proceeds to mate with her, curving his genital capsule until it comes into contact with her pointed abdomen – he secures his hold by means of the forceps at the tip.

In addition to diverting the female's attention, it is believed that the male's protein-rich saliva may be of nutritional value to the female for the proper maturation of her eggs. Rather unusually, fertilisation is direct in scorpion-flies, there being no sperm-capsule as in the case of most other insects.

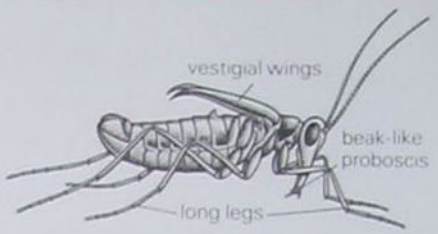
After mating the female scorpion-fly uses her pointed abdomen to insert her eggs in damp soil or rotting wood. Clusters of 12-20 eggs, each about one millimetre long and oval in shape, are laid, often adhering together in a mass. Up to 100 eggs are produced in all.

Caterpillar-like offspring Scorpion-fly larvae are of the eruciform (caterpillar) type, with three pairs of wiry legs just behind the head and, initially, eight pairs of false legs (pseudopodia) on the abdominal segments. The number of false legs immediately distinguishes them from butterfly and moth caterpillars, which have a maximum of five pairs, and sawfly larvae, which possess six or seven pairs. The scorpion-fly larvae's abdominal limbs begin to degenerate after the first skin change, when the larvae become more grub-like and less mobile. Adapted primarily for a burrowing life in soil, the larvae appear to move by means of bristled tubercles on their upper surfaces. Whitish in colour, scorpion-fly larvae attain a maximum length of 8-12mm ($\frac{1}{3}$-$\frac{1}{2}$in). They hibernate during the winter.

Pupation takes place the following spring within a small earth chamber lined with silk. The pupae are of the exarate type (with free but largely immobile limbs), although the jaws are capable of biting at this stage. The adults emerge about a month later.

Leaping snow flea

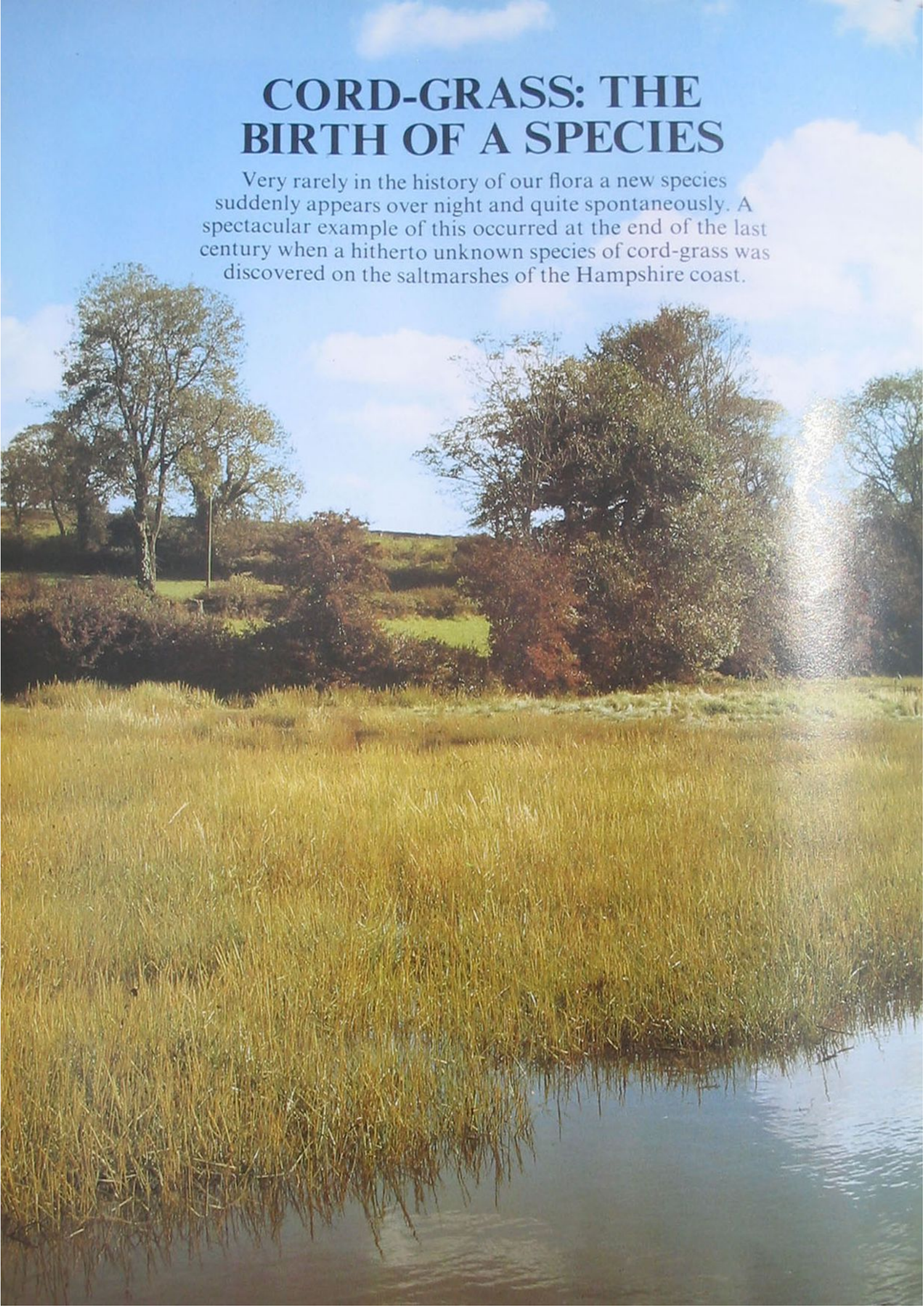
Our fourth scorpion-fly, the snow flea (*Boreus hyemalis*), displays so many differences from the *Panorpa* species that some authorities consider it to be in a separate order – the Neomecoptera. It is 3-5mm long and a green or bronzy colour; it has a beak-like head and long legs, although both sexes have only vestigial wings. On the female these are useless, but the male's are adapted for holding on to the female while mating – he has no genital capsule. Snow fleas gain their name from their ability to run and jump rapidly. Commonest in northern England and Scotland, they prefer high woodland areas, especially near oak and birch and where hair-moss (right) occurs. They are seen from October to April on sunny, windless days running over rocks, tree-stumps, and even snow and ice.



Below: Scorpion-flies mating. As in many other insect groups, courtship and mating are not without risk to the male, who may be attacked by the female before completing his duty. To subdue his partner he exudes saliva on to a leaf for her to feed on while he attempts to mate.

CORD-GRASS: THE BIRTH OF A SPECIES

Very rarely in the history of our flora a new species suddenly appears over night and quite spontaneously. A spectacular example of this occurred at the end of the last century when a hitherto unknown species of cord-grass was discovered on the saltmarshes of the Hampshire coast.



The evolution of a new species from an existing one usually takes a long time and is scarcely detectable even after many generations. In higher animals we can be sure when an individual belongs to one species or another because animals from different species, although they may be able to mate together, cannot produce fertile offspring. Thus the main mechanism of evolution among animals is the slow adaptation of a species in response to changing conditions in the environment.

Flowering plants, however, have found a way round this predicament so that new species can appear literally overnight, rather than taking generations to evolve. The way in which this can happen is very much a matter of chance (it involves the chromosomes of the parents and the hybrid). Yet it is one of the principal driving forces of plant evolution and it has happened more than once in the British flora. The best-known example of this phenomenon occurred in the cord-grass genus, *Spartina*.

Cord-grass structure The cord-grasses form a very distinctive genus of maritime grasses inhabiting mudflats and saltmarshes. They are stout perennials with thick tough leaves and extensively creeping rhizomes. The inflorescence consists of a number of short, erect spikes arranged along an axis. Each spike bears two alternate rows of spikelets pressed close to its axis. The spikelets each have a single flower with glumes unequal in length, one of them being longer than the floret.

Until the beginning of the 19th century there was only one species of cord-grass in the British Isles, small cord-grass (*Spartina maritima*). This species is characterised by its glumes, which bear soft, short hairs, and its anthers, which are not more than 8mm long. It has an uneven distribution in the British Isles, occurring sporadically along the southern and eastern coasts of England from south Lincolnshire to south Devon, and also in South Wales and south-eastern Ireland. It grows on the fringes of gullies and in shallow pools and pans.

American invader Small cord-grass remained the only species of *Spartina* in Britain until 1829, when a certain Dr Broomfield noticed an unfamiliar cord-grass in the estuary of the River Itchen near Southampton Water. It turned out to be a North American species, *Spartina alterniflora*, which had been accidentally introduced via a ship. It differs from small cord-grass in its glumes, which have extremely short hairs or are just slightly rough, its larger size and its longer leaves.

During the next 40 years it steadily spread along the coast of Hampshire as far west as Lymington, becoming quite common in some places.

A hybrid appears It was inevitable that the British and American cord-grasses would eventually come into contact and interbreed, and the first reports that they had indeed done so came in 1870. The hybrid plants in question were, in most respects, similar to the American species but with one very important difference: the anthers were completely devoid of viable pollen and did not even open at maturity. In grasses this is usually a sure sign that the plant is of hybrid origin. It was named Townsend's cord-grass (*Spartina* × *townsendii*).

Although sterile, Townsend's cord-grass is a large, robust plant and displays what is known as hybrid vigour, in which the characteristics inherited by the hybrid give it a lease of life not known to either of its parents. Slowly but inexorably this hybrid has spread over tidal mudflats from Poole Harbour in the west to Chichester in the east. New colonies establish themselves not by seed, because none is set, but by whole plants or just fragments of rhizome being uprooted and washed along the coast by storms and extra high tides.

So relentless has been the spread of Townsend's cord-grass that the range of its American parent has contracted until it is now no longer found beyond the locality where it was first discovered, and it may no longer even be there. The extraordinary ability of this plant to invade tidal mud – sometimes to the exclusion of other species – means that it is ideal for planting in areas where the tidal mud needs to be stabilised for land reclamation schemes. It has been planted for just this purpose in several places, from west Norfolk to Dublin and Gwynedd.

A new species Towards the end of the last century a remarkable event occurred. In 1892, on a saltmarsh at Lymington, a plant was discovered resembling Townsend's cord-grass but with broader leaves and some differences in the flowers. Most remarkable of all was the

Townsend's cord-grass (*Spartina* × *townsendii*)

Above: Townsend's cord-grass grows to 1.3m (4½ft) tall, which is more than twice the height of its British parent, small cord-grass.

Opposite page: Townsend's cord-grass spreading along the River Carew in Dyfed.

Below: *S. alterniflora*, an American species naturalised here and one of the parents of Townsend's cord-grass.

Right: A flowering stalk of our original native species, small cord-grass. Each flower lies close to the stalk and has a pair of feathery stigmas and several straight anthers protruding between blade-like glumes. Differences between the glumes and the anthers of the various species of cord-grass can be a guide to telling them apart.

Below: All members of a particular species have the same set of chromosomes and are therefore capable of interbreeding to produce fertile young. When two different species—whether plant or animal—interbreed they may still produce young if their chromosomes are similar enough, but it will be sterile. An example is the mule, which is a sterile hybrid between the horse and the donkey. In plants, however, it is possible for two different species to produce a fertile plant, which has to be regarded as a new species. This is what happened to *Spartina*.

fact that the anthers were perfectly formed and produced fertile pollen.

In 1893 similar plants were found on the Isle of Wight and, by 1900, they could be seen scattered along the coast from Poole to Chichester. In the following years it spread very rapidly and, by 1907, it covered many thousands of acres between Sussex and Dorset. Today it can be found in all suitable habitats in England and Wales, and introductions by man have extended its range still further into Scotland and Ireland.

The plant has been named *Spartina anglica* and scientists are agreed that it can have had only one possible origin: it is a version of Townsend's cord-grass in which, by chance, the number of chromosomes has doubled to produce a fertile hybrid. Because of the doubling of chromosomes, such hybrids have a very rich stock of genes from which to draw. Thus they are often able to extend the range of their parents into areas previously unsuitable.

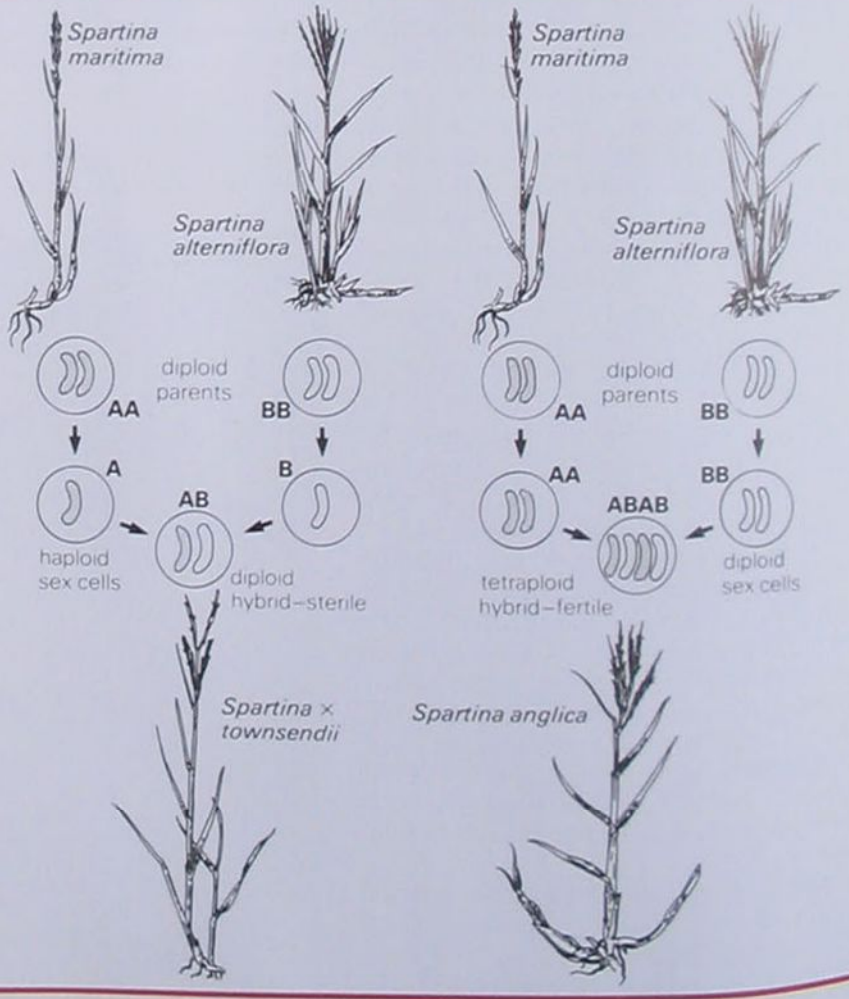
Because *S. anglica* is a fertile plant capable of reproducing itself from seed, the multiplication sign, used in names to signify a hybrid, is dropped. The plant is no longer simply a hybrid but a new species in its own right.

A final twist The story of *Spartina* does not quite end there. From time to time, Townsend's cord-grass appears in places where it was never known before. Yet, with increasing competition from *S. anglica*, it has been getting scarcer. So how do we account for these sporadic occurrences within populations of the new species? The answer, unbelievable though it may seem, is that these plants derive from *S. anglica*—they occur when the chromosome number of this species is accidentally halved, bringing it back to the infertile form, which is of course Townsend's cord-grass.

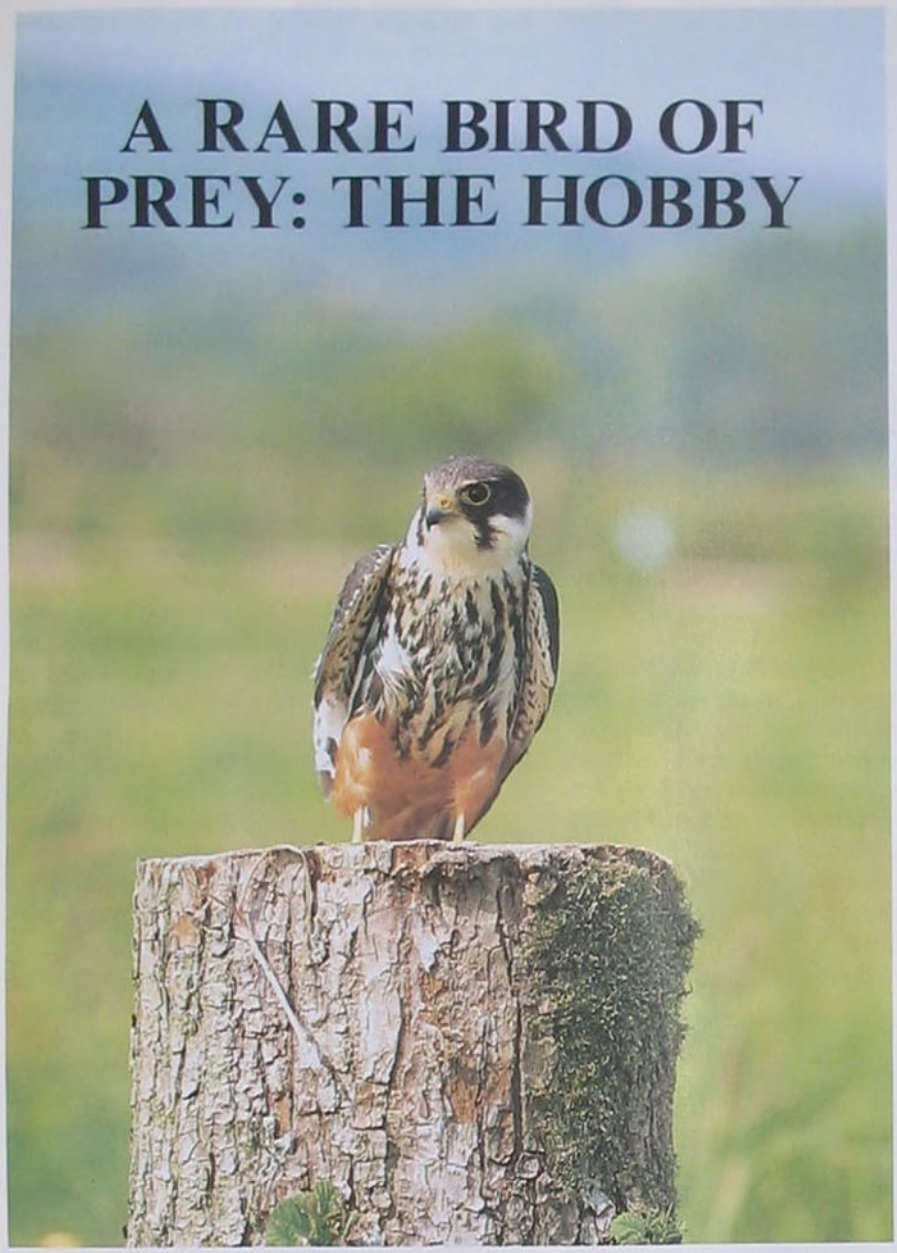
Creating a new species

The cells of a normal individual are said to be diploid because they have two identical sets of chromosomes, say 'AA'. Its sex cells are haploid because they contain just one set of chromosomes, 'A'; when two sex cells fuse to form a fertilised egg or seed the chromosomes re-form the parents' 'AA' configuration. Consider two distinct but closely related species. Their chromosomes are different, say 'AA' and 'BB', and the chromosomes of their sex cells are 'A' and 'B'. When the sex cells fuse, therefore, the product is a hybrid 'AB' and, because the two sets of chromosomes do not match, the hybrid is sterile.

Occasionally, however, a mistake is made in the production of the sex cells and they end up as diploid individuals instead of haploid. If two such cells fuse the product is tetraploid with four sets of chromosomes. In the case of two different species hybridising, the diploid sex cells, 'AA' and 'BB' fuse to give the tetraploid hybrid 'AABB'. This seems as though it ought to cause all sorts of problems for the offspring, but in fact the result may be a fertile hybrid because the tetraploid set can be considered to consist of two matched sets of chromosomes, each labelled 'AB'. This hybrid, being fertile, must be regarded as a new species.



A RARE BIRD OF PREY: THE HOBBY



The hobby is a rare sight as only 100 pairs nest in Britain, gracing our countryside for four months of the year before returning to Africa.

Birds of prey have long held a fascination for man, some–for instance the golden eagle, peregrine and sparrowhawk–being the inspiration of many writers. The hobby, however, is one species often neglected.

The reason for this neglect appears to be the hobby's avoidance of urban and most agricultural areas and also of those wild mountainous and cliff habitats that provide the aura of romance surrounding the golden eagle and peregrine. Its rarity must also contribute to this neglect, for the hobby's ability to live in Britain depends upon the abundance of summer insects which form a substantial part of its diet; when the numbers diminish in winter the hobby returns to its wintering grounds in the savannas of tropical Africa.

Recognising the hobby Although little known, in its appearance and agile pursuit of aerial prey the hobby rates as one of our most elegant birds. It is about the size of a kestrel but has longer wings and a shorter tail–features that confer the ability to fly fast, but with amazing manoeuvrability. In fast flight it often resembles a large swift with the wings held more or less rigid and sickle-shaped.

The adult male and female are very similar; the back, upper-wings and crown of both are a slaty grey colour. A black stripe runs below each eye, like a moustache, on to the whitish-cream chin and throat; the pale colouring extends round the neck as a broken collar. The breast in both sexes is pale buff, heavily streaked with black, and the tail is grey. These sombre colours are interrupted by the bright rufous thighs, lower belly and under-tail coverts (which, however, are not often conspicuous).

Dynamic aerobat Hobbies arrive at their nesting areas mainly during May. The males usually appear a few days ahead of the females, but occasionally they arrive already paired.

The male advertises his territory by his aerobatic displays, which involve low swooping flights around the tree-tops, and also soaring high above the trees–this soaring flight can be so high that the birds are almost invisble to the naked eye, although their presence is betrayed by repeated 'kyu kyu kyu' calls. On some of these high flights the male may carry prey in his talons.

When the female is present display flights can be even more spectacular, with the male chasing his mate and swooping round her, looping the loop and even performing victory rolls. During courtship the cock passes food to his mate in mid-flight–a remarkable aerial

Above: An adult hobby perching on a tree stump. Notice the black mark which extends like a moustache over its white collar.

Left: Three hobby chicks, covered in cream and white down at 2½ weeks old.

Above: The female hobby normally lays three eggs in the disused nest of another species—a crow's nest or even a squirrel's drey. The eggs, 4.2cm (1½in) long, 3.3cm (1in) wide, and pale with reddish-brown spots, are still prized items for egg collectors.

Below: A week after hatching the chick's down is replaced by coarse, grey downy feathers. Their flight feathers appear a week later, and they fledge when four to five weeks old.

feat. The pair converge in fast flight, suddenly rolling sideways so that the hen can take an item of prey from the male's talons. Sometimes the male even drops food to be caught by his mate.

Nest and chicks The pair may take several weeks after their arrival to select an eyrie. This is usually the disused nest of a crow, although other species' nests are also used. The hobbies may remove the nest lining but they add nothing to the existing structure. They prefer nest sites in isolated groups of trees surrounded by expanses of open ground, such as those found on the downs and heaths of southern England.

The female lays three eggs, each one at two day intervals, and starts incubating after laying the second egg. The third egg thus hatches somewhat later than the first two, so the third chick is smaller than its siblings.

Learning the hunting technique The young birds leave the nest after four or five weeks and begin to catch insects for themselves. Remarkably, they also learn to take food from their parents in mid-air. Their ability to catch food in this way, and especially to hunt prey for themselves, requires co-ordination and a considerable amount of learning. To this end young birds spend much time in playful manoeuvres, diving on parents, other juveniles and even large birds such as crows. Only towards the end of their dependence upon the adults do they begin to practise hunting agile prey such as birds.

Female hobbies mature at one year old and may attempt to breed with older males; the males are not mature until they are two years old. This delay in breeding, especially by the male, may be an indication of the length of time hobbies need in order to learn to catch their prey.

Sky-high hunters Hobbies hunt mainly in the open sky. In their African wintering grounds they obtain an abundant supply of winged termites, but during their short stay in Britain they have to rely on such high-flying insects as moths, beetles and flying ants. At times, however, they hunt for low-flying prey, especially large insects such as dragonflies. All insects are eaten while the hobby is in flight.

When the male is feeding a hungry family, however, he generally selects larger prey—mainly birds of the open sky (skylarks, pipits, swallows, house martins and swifts), although bats have occasionally been taken. Hobbies are opportunist birds and the inclusion of sparrows in the menu indicates that hobbies also feed near to the ground and close to buildings and hedges. A somewhat surprising item recorded in their diets is the budgerigar; birds escaped from captivity and inexperienced in the ways of the outside world seem an easy target for the hobby.

The lack of experience in the prey species possibly plays an important role in the life of the hobby. The birds which figure prominently in its diet are the hirundines (swallows and martins) and the swifts, all very fast and agile birds. Consequently, most individuals brought back to the nest are juveniles—naive birds which have not yet developed their parents' skills of manoeuvrability and predator avoidance. These juveniles only become available in large numbers in June so this is the best time for the hobby to rear its young. It is probably for this reason that the hobby lays its eggs at least a month later than our other falcons. The hobby's dependence upon aerial food, ultimately derived from the summer flush of insects, is undoubtedly why it only spends a short time in Britain every year.

Peregrine. Wingspan 87-117cm (31-46in). Female largest.

Hobby. Wingspan 69-77cm (27-30in). Female largest.

Merlin. Wingspan 52-69cm (20-27in). **Kestrel**. Wingspan 68-82cm (26-32in).

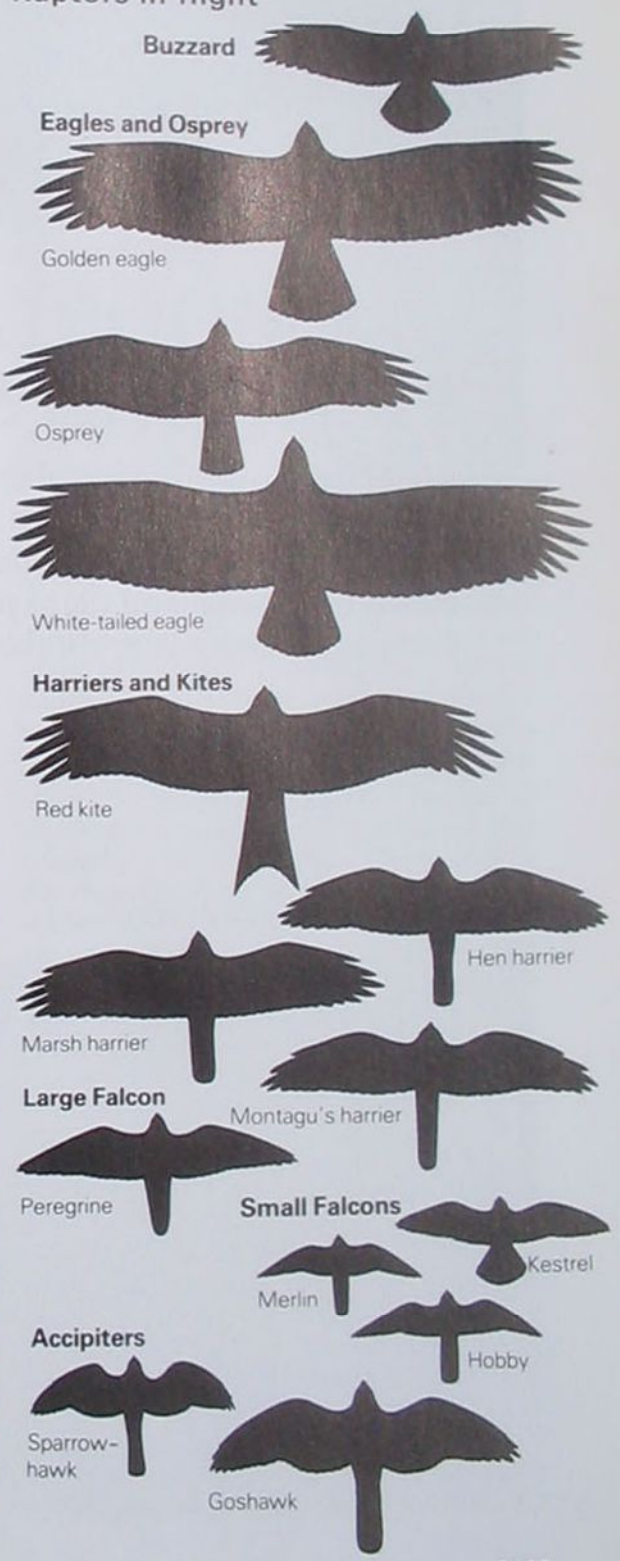
Status in Britain The brevity of its visits and its particular selection of food items appear to have put the hobby at an advantage over many other birds of prey. Most species have suffered drastically in the last 150 years at the hands of gamekeepers and, more recently, through the use of toxic chemicals. But the hobby's preference for open heaths and downs have freed it from the ravages of the gamekeeper, and its brief stay in the northern hemisphere, together with a diet largely unaffected by agrochemicals, have given it relative immunity to poisonous chemicals. Thus while birds such as the sparrowhawk and peregrine have declined alarmingly, the hobby maintains its numbers, albeit at a low population level.

Despite the hobby's preference for non-agricultural land and its lack of interest in game it is still shot, and also remains a favourite quarry for the egg collector. These two factors are probably the main cause of nesting failure in Britain. Its scarcity and habits lead the hobby to be overlooked and underrated, and yet it is undoubtedly one of the most elegant and aerobatic of all the birds of prey found in Britain.

Hobby (*Falco subbuteo*). Summer visitor to open heaths and downs of southern England. Length 38-48cm (15-19in). Sexes have similar plumage.

Below: The growing hobby chicks being fed by their mother. Although the female feeds and broods the chicks, the male collects all the food, presenting it to his mate on the nest. During the first week the hen tears off food chunks and gives them to her chicks, but after two weeks they tear their own pieces of food off the carcases brought by the male. During the later stages of the chicks' growth, the hen may help the male with hunting. Soon after fledging the female juveniles begin to catch insects for themselves.

Raptors in flight



A MOORLAND FISHPOND STUDY

Hodson's Tarn, one of a number of small 'fishponds' on the lower fells of the Lake District, has been under study since 1954, revealing a cycle of events in which the animal and plant population develop, decline and become re-established once more.

A fishpond is an area of water large enough to support a viable population of fishes – trout for example – that attain a size sufficient to interest the angler. It is also generally several acres in extent. Such fishponds are common in upland moorland areas and are often artificial, having been created by the damming of a valley to provide drinking water, electric power or sporting facilities. There are many such fishponds, or tarns as they are called locally, on the lower fells of the Lake District. Their basin and drainage areas are generally of rock thinly covered with soil and therefore rain quickly finds its way into them.

Two Lake District tarns have been well studied and one – Hodson's Tarn – is about an acre in extent and 2.7m (9ft) deep at its deepest point. Its drainage area covers about 12 hectares (30 acres).

The fluctuating vegetation When observations started in 1954, vegetation covered all of Hodson's Tarn. The deepest regions were covered with floating-leaved pondweed near the inflow and milfoil elsewhere. In shallow water there were swards of lakewort, replaced near the inflow by beaked sedge. Of this vegetation, the only plant to spread steadily has been the floating-leaved pondweed. Milfoil almost died out in the 1960's, leaving much of the bottom without vegetation – a phenomenon which, although not infrequent in fresh water, has still to be explained (on land every piece of soil is colonized, provided that it is wet enough). The sedge was growing uniformly over a relatively large area in 1954, then gaps began to appear and by 1961 growth was vigorous only at the periphery of the bed.

However, recovery eventually took place and by 1973 the patch looked exactly as it had in 1954. Today the bed is back to the 'fairy-ring' stage. It seems likely that the slow decay of a copious fall of dead leaves renders the soil unsuitable for plant growth for a few years.

Animal inhabitants No animal species is unique to moorland fishponds. Nearest to characteristic species are two lesser water boatmen – *Sigara scotti* and *Sigarocorixa castanea* – but both also abound in much smaller bodies of water. On the other hand, from a list of the more abundant species, with some indication of their numbers, an experienced researcher can often provide an accurate description of the place from where they came. Often species not found reveal as much about conditions as those that do occur. For example, in Hodson's Tarn there is only one species of snail, and other notable absences are the flatworm and the hoglouse *Asellus*.

The herbivores of the tarn do not feed much on the living tissues of rooted plants, the basic food supply of most of them appearing to be dead leaves and algae (both those floating free in the water and those attached to rooted plants). The animals consuming this food include five species of mayfly, one species of stonefly, several species of caddisfly, the freshwater shrimp *Gammarus* and the wandering snail *Lymnaea peregra*. The groups which appear to provide the greatest

Above: A view of Hodson's Tarn from the bank above the pool.

Below: A lesser water boatman – two species are typical of moorland ponds.

Above: A caddisfly resting on a leaf blade. Several species of caddis live in Hodson's Tarn, including two of the net-spinning type.

Right: *Pyrrhosoma nymphula* damselflies are common inhabitants of the pond. The female of this pair, supported by the male, is laying her eggs. When the pond is crowded not all the nymphs of this species can reach full size.

Below: Brown trout – the principal predators in moorland fishponds. In an experiment to discover the effects of predation on the pond's inhabitants, the trout were removed from Hodson's Tarn for five years, then restored. From studies made during this period it appeared that the *Pyrrhosoma* nymph population remained fairly constant – the starveling nymphs were able to replace the larger ones eaten by the trout.

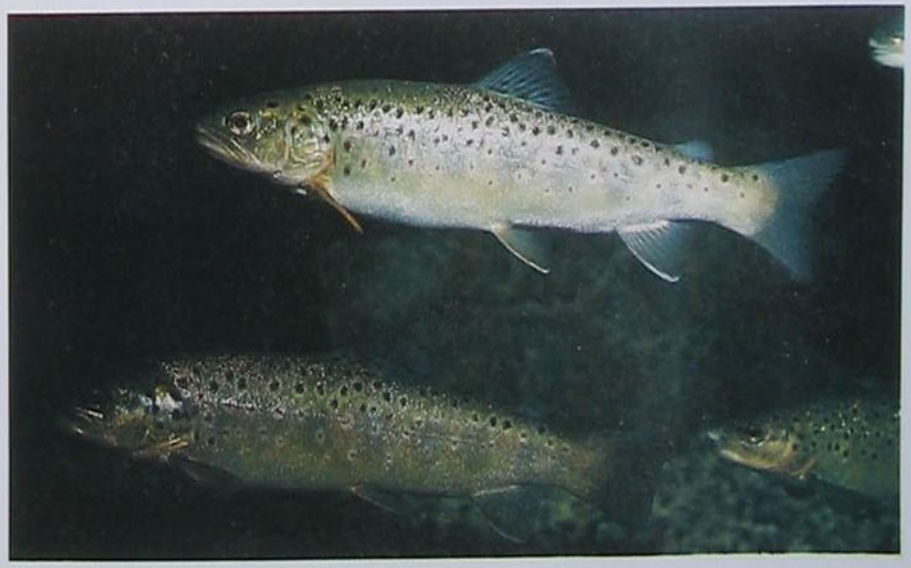
quantity of food for the carnivores are the chironomid larvae and the small crustaceans. Chironomid larvae, of which 40 species were found in a nearby tarn, occur everywhere, but many are adapted to live in mud.

The main carnivore is the trout, which feeds on anything it sees moving. Large organisms are taken when they can be found, and the diet changes predictably with the life-histories of the prey, though there is often, in a group of fish, a specialist which has taken more of one item of food than any of its fellows. Other active hunters, such as the beetles and bugs, are scarce and largely confined to shallow water, especially where sedges or other vegetation protect them from fish. Leeches are also carnivorous but are handicapped by a lack of seizing organs. Other carnivores lie in wait until their prey comes to them. Dragonfly nymphs, of which there are several species in the tarn, conceal themselves in the vegetation and seize passing prey by means of a hinged organ which can be projected from the underside of the head. Two species of caddisfly spin nets and catch organisms that swim into them, while the larvae of the alderfly *Sialis* lurk in the mud.

The struggle for existence A knowledge of how these various animals interact to form a community demands information about their size and their whereabouts at different seasons of the year. There are, for instance, two species of mayfly of the genus *Leptophlebia* in the tarn, both of them abundant and both widely distributed; one emerges earlier than the other and is larger, which means that there is not a complete overlap in the food taken. The adults emerge in May and June.

Active life starts at about the same time for nymphs of the bright red damselfly *Pyrrhosoma nymphula*, but growth soon ceases and the nymphs overwinter at a length of 2-4mm. Development starts again when the weather turns warmer and by the end of summer most nymphs are full-grown, at about 12-14mm long. A second winter is passed in the water and the adults emerge in May or June. This is the course of events when nymphs are not closely crowded; when they are numerous only some are nearing full size by the autumn, while the rest are scarcely half-sized. These 'starvelings', as they can be called, require a second summer to achieve full size, and must spend a third winter in the water. The explanation for this probably lies in some sort of territorial behaviour: the larger, more robust nymphs take possession of vantage points from which plenty of food can be caught and relegate their less vigorous siblings to places where the food available suffices only for meagre growth.

Experimental results These starveling dam-



selflies have helped with the interpretation of findings in the main experiment conducted in the tarn – an investigation to discover what effect predation has on the rest of the animals. Trout were removed, the community was studied for five years, then the trout were restored. The study continued, together with an examination of what the trout had eaten. The effect of predation on *Pyrrhosoma* appeared to be slight, for the numbers ready to emerge in spring were little lower after the trout had been re-introduced. Yet trout fed readily on these nymphs, nearly always choosing the large ones – probably those that had incautiously exposed themselves too close to the edge of the vegetation which provided cover from enemies. The suggestion is that, when a large nymph is taken, its good feeding place is quickly occupied by a starveling, which is then able to grow. These small specimens provide a reserve from which losses in the ranks of the larger ones are made good.

Predation did not appear to deplete seriously the numbers of any of the animals that lived a sheltered life in the vegetation. It was the active swimmers whose numbers were reduced and whose range was restricted to the shallow areas behind the beds of sedge. When the lakewort almost disappeared the number of damselfly nymphs dropped sharply, presumably because there was less shelter from predation. As the vegetation recovered, the nymphs regained their earlier abundance.

Above: A number of common blue damselflies (*Enallagma cyathigerum*) – some are in flight. Whereas *Pyrrhosoma* damselflies lay their eggs into the stalk of a leaf simply by inserting the tip of the abdomen just below the surface of the water, *Enallagma* damselflies crawl down a plant stalk right into the water to a depth well below the point of entry. *Enallagma*, like *Pyrrhosoma*, is commonly seen in moorland fishponds.

Below: There is only one species of snail in Hodson's Tarn – the wandering snail *Lymnaea peregra*, shown here crawling over underwater weeds.

Spatial distribution The common blue damselfly *Enallagma cyathigerum*, another abundant inhabitant of the tarn community, resembles *Pyrrhosoma* closely in life-history and in feeding habits but lays eggs in a different place. Pairs of *Pyrrhosoma* could be seen alighting on the floating leaves of the pondweed, the female then immersing her abdomen to insert her eggs, one by one, into the stalk of a leaf. There is some evidence that the nymphs fresh from the egg lead a planktonic existence and presumably come to rest when they drift into shallow water. The observation at Hodson's Tarn was that later most of the small nymphs were found in shallow water. Pairs of *Enallagma*, however, alighted on the tiny inflorescences of milfoil which projected a few millimetres above the water surface. The female then crawled down into the water to lay her eggs well below the point of entry. The process completed, she had only to let go and a bubble of air between her wings brought her swiftly to the surface.

Something about the distribution of *Enallagma* nymphs was discovered during the course of experiments with methods of sampling. A net would not reach the deeper parts of the tarn and, to ascertain what lived there and to make comparisons, mats of artificial vegetation made from polypropylene rope were laid down in all parts of the tarn. Not unexpectedly, a high proportion of *Enallagma* nymphs was found on the mats in deep water during the first winter. A decrease in the summer was attributed to dispersal among natural vegetation as well as to natural mortality. During the second winter there was a return to the artificial vegetation, but now numbers were higher in the shallow water.

Sheets of plastic, some flat and some pleated, were suspended in mid-water and removed at intervals for examination and cleaning. At one time or another most of the common animals in the tarn were found on these sheets, which indicated an unexpected amount of movement. The two net-spinning caddis larvae, normally found near the outer edge of tufts of vegetation, evidently found the flat sheets an excellent substratum for their nests, and specimens were found on a sheet that had been cleared only a week previously. Comparison of the numbers on the three types of substratum gave an indication of the natural habits of the various species. *Enallagma* and *Leptophlebia*, for instance, both sought cover.

SAVING THE LITTLE TERN

The little tern used to be a seriously endangered species and is still under strict protection, but now conservation work has helped cause a rise in numbers.

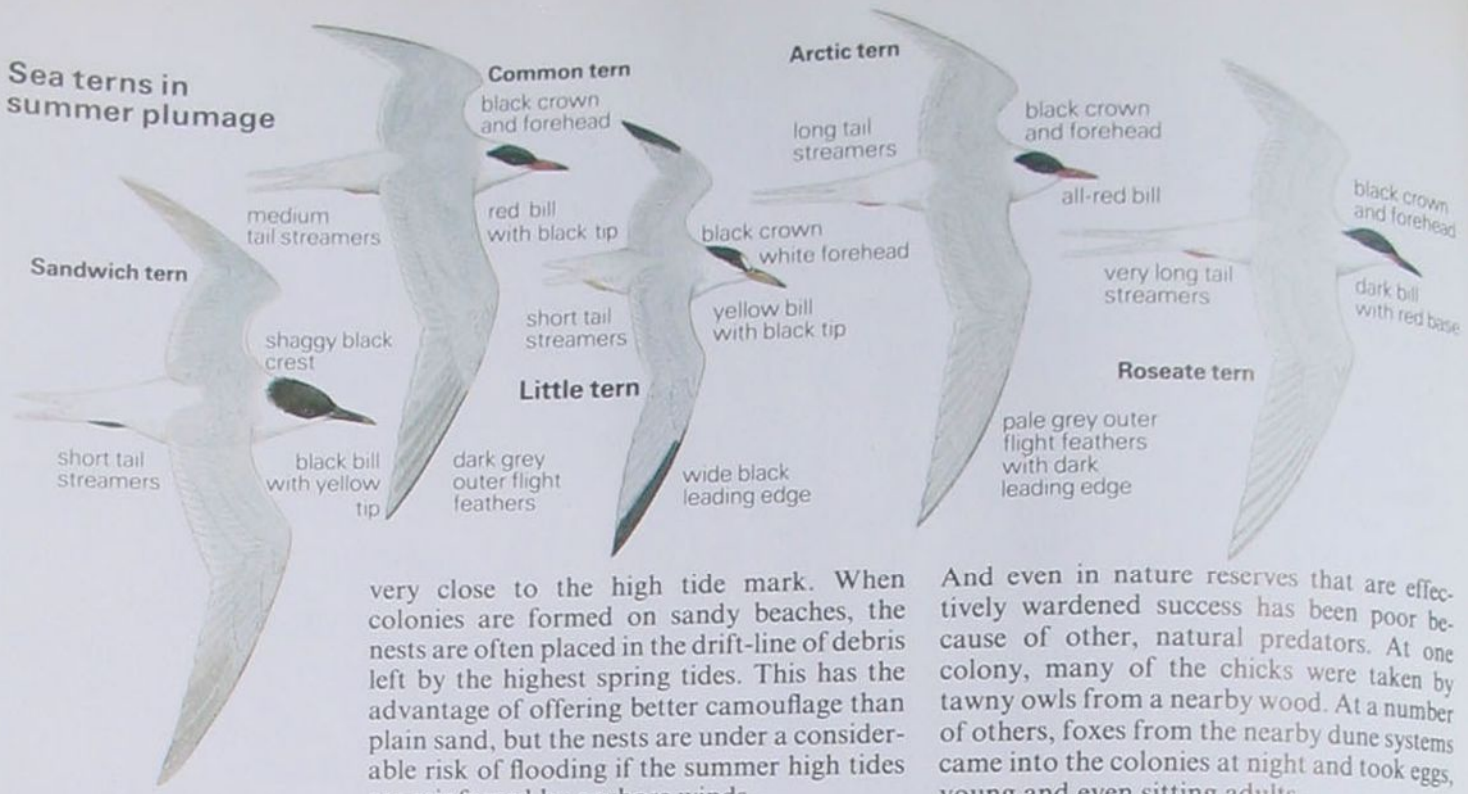
The little tern is the smallest of the British and Irish terns. Like the others, it is a summer visitor to our coasts, and feeds by fishing in the sea, in estuaries, in rivers or even lakes. Its legs and bill are mainly yellow and, in all plumages, it is a very white bird. The breeding plumage gives the bird its specific name *albifrons*, for it has a strikingly white forehead, and this is precisely what the Latin word means.

The white plumage is thought to have evolved to make the bird less conspicuous against the sky when seen through the surface of the water by its prey (mainly fish). The white underparts merge into the brightness of the sky and the white forehead is also part of this camouflage. Feeding birds often hover, peering intently down into the water and, if their black caps were to extend on to the forehead, they would be conspicuous.

Colonial nesting Most tern species are strongly colonial, and the nests of such species as common, Arctic and Sandwich terns are always packed densely into small areas. The little tern is colonial, too, but its colonies are not nearly as dense as those of the other species. Typically, the nests are tens of metres apart. They are often made on shingle–for example the shingle banks that run along the coast (shingle spits) or the shingle 'bars' that form across the mouths of some estuaries. The chosen substrate is not always shingle, however; small pebbles or sand are also suitable, but it is generally a substrate with a 'broken-up' pattern, against which the birds' eggs are well camouflaged.

Most colonies are situated on the sea-shore,

Above: A little tern incubates its eggs on its nest on the beach. Most of the little tern colonies on beaches accessible to the public have now ceased to be active: the birds have deserted them. The only thriving ones in Britain are those wardened by conservationists.



Above: The five species of sea tern that breed in Britain and Ireland. The rarest is the roseate tern, while the little tern is second rarest.

Little tern (*Sterna albifrons*). Smallest British sea tern; summer visitor to shingle and sandy beaches. Sexes alike; 24cm (9½in).

Below: An example of the type of sandy beach that attracts little terns. The nests tend to be spaced wide apart, along the strandline.

very close to the high tide mark. When colonies are formed on sandy beaches, the nests are often placed in the drift-line of debris left by the highest spring tides. This has the advantage of offering better camouflage than plain sand, but the nests are under a considerable risk of flooding if the summer high tides are reinforced by onshore winds.

A precarious life The little terns' choice of nesting sites often coincides with the sites chosen by human holiday-makers for their recreation. The birds can tolerate a little disturbance, but constant passage backwards and forwards by holiday-makers not only causes the birds to desert their nests, but inevitably results in crushed eggs. The camouflage is so good that the unsuspecting people do not realise that they are treading on a nest until it is too late.

Unfortunately, unwitting disturbance and destruction by humans is by no means the only danger faced by the nesting birds. Although the species is fully protected by conservation laws, its superbly camouflaged eggs are still much sought after by collectors. And even in nature reserves that are effectively wardened success has been poor because of other, natural predators. At one colony, many of the chicks were taken by tawny owls from a nearby wood. At a number of others, foxes from the nearby dune systems came into the colonies at night and took eggs, young and even sitting adults.

Protecting the species The little tern is one of our rarest seabirds, with a nesting population during the last 20 years as low as 1500-1600 pairs. Recent estimates indicate a fairly good recovery, and now there are certainly more than 2000 pairs. Many of these now nest in protected habitats at colonies which have built up into veritable 'little tern cities'.

Management of reserves includes control of the foxes. In one reserve, to avoid shooting the foxes, low electric fences were erected to keep them out—although at least one fox learnt that it could swim round the seaward end of the fence without receiving a shock! The threat of extreme high tides in summer has been met, in some cases, by the assiduous work of wardens lifting the eggs from scrapes at times of very

high tides, taking them into safe keeping and then replacing them when the tides resumed their normal pattern. The trusting little terns almost always come back after this has been done, and carry on incubating as if nothing had happened.

Migratory flights Little terns are migrants, flying to tropical West Africa for the winter, sometimes as far as Ghana. Return passage in the spring is through north Africa and southern Europe. It takes place in April and May, and the birds are established on the breeding grounds in Britain and Ireland by the second half of May or early June.

Breeding displays Little terns have elaborate and beautiful displays which result in the formation of a strong pair-bond between the male and female. In one of the displays the male arrives with a fish and ascends rapidly to about 100m (300ft) above the area he has chosen for nesting. This attracts the attention of the female, and she rises to pursue him as he glides down, in a series of broad, graceful spirals, almost to ground level. Additional females may join in, but soon the male gives all his attention to the mate he has selected. The pair then performs a ritual in which the birds exchange fishes with one another.

As breeding begins, the male feeds the female: this reaches its peak as she starts to lay the clutch. As often as five or six times an hour the male offers her a single small fish. The fishes are caught close to the colony, generally in shallow water where suitable small species are abundant.

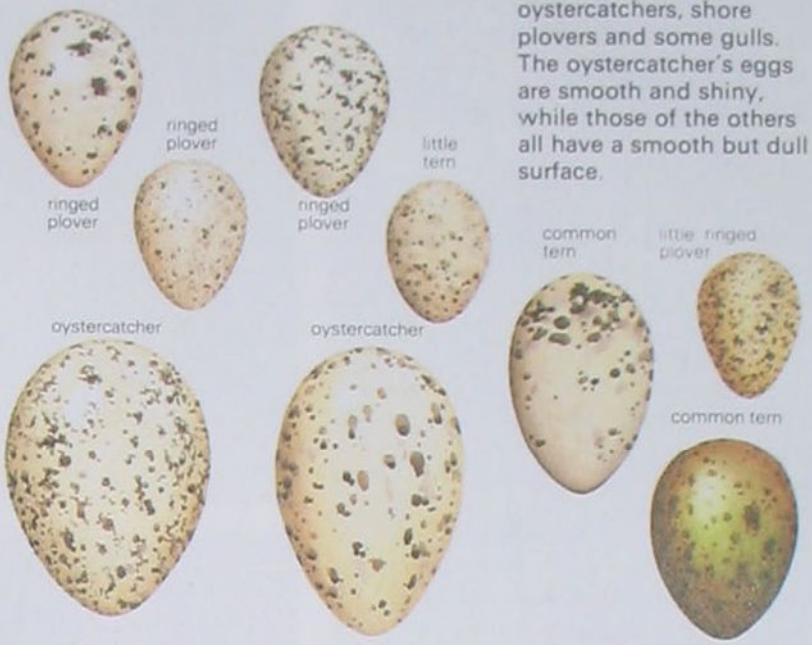
Learning to catch fish The young terns make their first flights when they are about three weeks old. Within a day or two, they start trying to dive for food. The plunge-diving and surface-dipping feeding techniques they use require a good deal of skill and practice. It may take the whole duration of the flight to winter quarters before the youngsters gain their full skills. The following summer the parents return to breed, but the young birds stay in Africa, usually for the whole summer, and return to the breeding area for the first time in their second full summer.

Mobbing defence Colonial nesting, even if the colonies are not as dense as those of many other species, has distinct advantages over solitary nesting; a benefit shown clearly in the case of little terns is that the parent terns are able to join together to mob any predator threatening the colony. This is particularly noticeable if a flying predator such as a sparrowhawk, gull or crow appears. Often every adult in the colony is on the tail of the intruder before it has begun to threaten any individual's nest; the mobbing birds even attack large birds such as great black-backed gulls.

Humans, dogs, stoats, weasels and foxes may all attract an agitated flock of little terns hovering over them. Every now and then a bird dives at the predator, possibly striking it or defecating on it. In Britain, birdwatchers who find they are provoking such activity are legally obliged to leave the area, for their presence surely constitutes 'wilfully disturbing' the birds, and the species is protected from such disturbance under the Wildlife and Countryside Act. This arrangement is no more than fair treatment for the birds, in view of the large-scale encroachments by holiday-makers on their nesting habitat.

Eggs of shingle nesting birds

Birds that nest on shingle include sea terns, oystercatchers, shore plovers and some gulls. The oystercatcher's eggs are smooth and shiny, while those of the others all have a smooth but dull surface.



Above: The eggs of shingle nesting birds are highly camouflaged. They need this protection for without it they would be extremely conspicuous in the simple 'scrape' nests made by all these species. Camouflage and the 'scrape' technique also enable little terns to colonize certain artificial sites, such as old, weathered concrete.

Left: A clutch of little tern eggs–difficult to spot even when you know that they are there.

Below: The fluffy chicks are superbly camouflaged against the sand. They remain by the scrape nest for a short time and then disperse in different directions. Each chick recognises its parents as they arrive bringing food.

Reading about mammals can be fascinating, but undoubtedly the most interesting aspect of their study is field work–watching them in the wild.

To be a successful mammal watcher it is essential to follow a few basic guidelines and do a little preparation before embarking on a field trip. The time and trouble are well worth the effort: mammal watching can be very rewarding.

Preparations To survive in the wild and escape predators, mammals need to know their environment intimately. This puts the mammal watcher in a new area at a disadvantage, and unless he or she can become unobtrusive, sightings are likely to be fleeting.

There are two main principles to follow: first, concentrate on one locality, and gradually gain knowledge and experience of watching the animals there. Second, try to be calm: the more patient you are and the greater your ability just to sit and wait rather than walk continuously in the hope that an animal will appear, the more you are likely to see.

Sign language When you visit a site for the first time, get to know the area and look for signs of mammals rather than for the mammals themselves. Most mammals keep to regular pathways within their territories. If you follow the wider paths through undergrowth and between trees in woodland you may come across the sett of a badger, a fox's earth or the lying-up area of deer. Tracks in

Above: A fox's earth in woodland. The best time to see foxes at their earth is during spring and early summer, when the cubs are being reared. If you are not sure whether the earth is occupied, bend down and smell inside the entrance: an occupied earth has a strong, musky smell. You may also see signs of freshly killed prey near the earth.

Left: The summer nest of a dormouse is built here among roses and bracken.

Dressing the part

The clothing you need depends on the habitat and time of year. Even in summer woodlands can be damp, cold places, so be prepared with warm, waterproof clothing, preferably in a drab brown or green colour (left). The more expensive purpose-made jackets will probably last a long time, but after a season of crawling through the undergrowth and along ditches any regularly used covering is likely to look the worse for wear, and a warm pullover and lightweight waterproof anorak will usually do the job just as well. Wellington boots keep the feet dry and protect legs from prickly undergrowth. If a lot of walking is involved or conditions are dry, a good pair of walking or hill boots will be more comfortable. Wear two pairs of socks–a thin pair underneath and a thick pair of climbing or thermal socks on top–to avoid blisters. A lightweight drab-coloured rucksack is useful for holding discarded pullovers, local maps, a notebook, a field guide and hand lens. And a lightweight pair of binoculars in the 7x50 to 10x50 range will help you to see shyer mammals from a distance. Keep them round your neck and ready for use, with the focus pre-set at mid-point, so you don't waste time finding or adjusting them.

the softer or muddier parts of the path will give many clues.

Mammals leave numerous signs of their activities, especially feeding remains. Split or gnawed nuts are a good sign that a rodent has been feeding – each species has a characteristic way of removing the kernel from a nut. In some cases it is also possible to tell whether the nut was opened by a juvenile or an adult – adult squirrels split a hazelnut cleanly in half, while the young tend to gnaw the shell.

Damage to the bark low down on a tree usually indicates browsing by rabbits; frayed stems and branches, and bark damage higher up, are likely to have been caused by deer. Squirrels also gnaw bark high in trees, especially during summer, to get at the sweet sappy tissue beneath.

When walking around a wood or farmland you may come across owl pellets beneath large trees or near derelict buildings. These pellets are the regurgitated indigestible remains of the owl's prey and are a good indication of the small mammals present. To separate the remains, break the pellet into two or three pieces and place them in water. When the pieces become softened, prise them gently apart, under water, using forceps. If the skull is present it should be clear which species the owl has eaten.

Right: The drey of a grey squirrel – one of the first mammals you are likely to encounter in deciduous woodland. A sign of their activity is a single branch bouncing about, even though there is no wind or sign of any large birds.

Below: A rabbit burrow among sea campion on a grassy cliff. For prolonged observation of rabbits over days or weeks, it is worth building a high seat overlooking the warren and baiting the area with food.

Fields and hedgerows These man-made environments offer many habitats for mammals. Farmlands are a significant haven for wildlife and many formerly woodland species find shelter there and in the hedgerows on their borders. When a train journey takes you through farming countryside, look out for mammals feeding in the fields. Rabbits will be seen most often, but occasionally foxes will be there as well, patrolling the hedgerows.

To watch rabbits more closely, creep quietly up to their grazing areas at dawn or dusk and observe them through binoculars. The best time is a sunny evening after heavy rain. Hares are found in greatest numbers on arable land, often in their simple forms in the grass or stubble. Watch in spring, when 'mad March hares' court and box in the fields.

Moles prefer to dig their tunnels in the soft soil of damp woodlands, but it is on pasture-land that their 'molehills' are most apparent. Moles are difficult to watch because their lives are spent mostly underground, but a mole's head may appear above the surface of a tunnel for a moment. Moles are occasionally seen above ground, especially after rain when earthworms come to the surface.

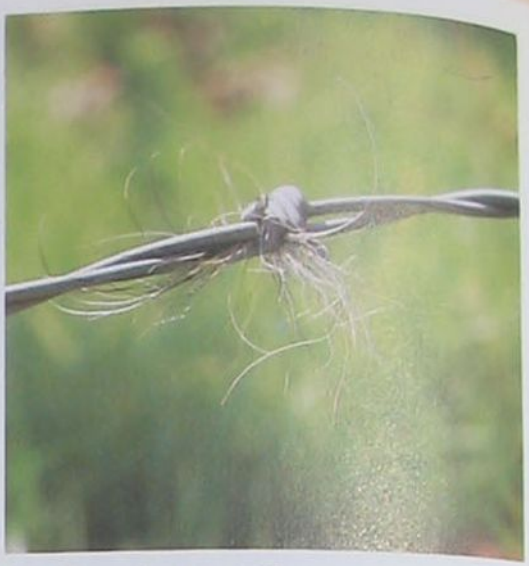
Above: The form of a hare. Hares are best watched from behind the cover of a wall or hedge, or from a vehicle parked at the end of a field. Farmland mammals are accustomed to vehicles in their habitat and soon learn to ignore them.

The hedgerow bordering the fields may be hundreds of years old and provide shelter for many field mammals in the verge, ditch and bank. Shrews, for example, live and hunt in the dense leaf-litter at the base, and if you watch a hedgerow regularly, listening for scratchings and rustlings, you will catch a glimpse of these and other small mammals, such as bank voles and wood mice.

Hedgehogs are most easily observed in gardens but the activity of the wild hedgehog is only a little more difficult to watch. Hedgehogs are mainly active from dusk, and you may hear them before you see them, as they snuffle and grunt through regular pathways in the undergrowth. You can often follow at a distance without causing disturbance.

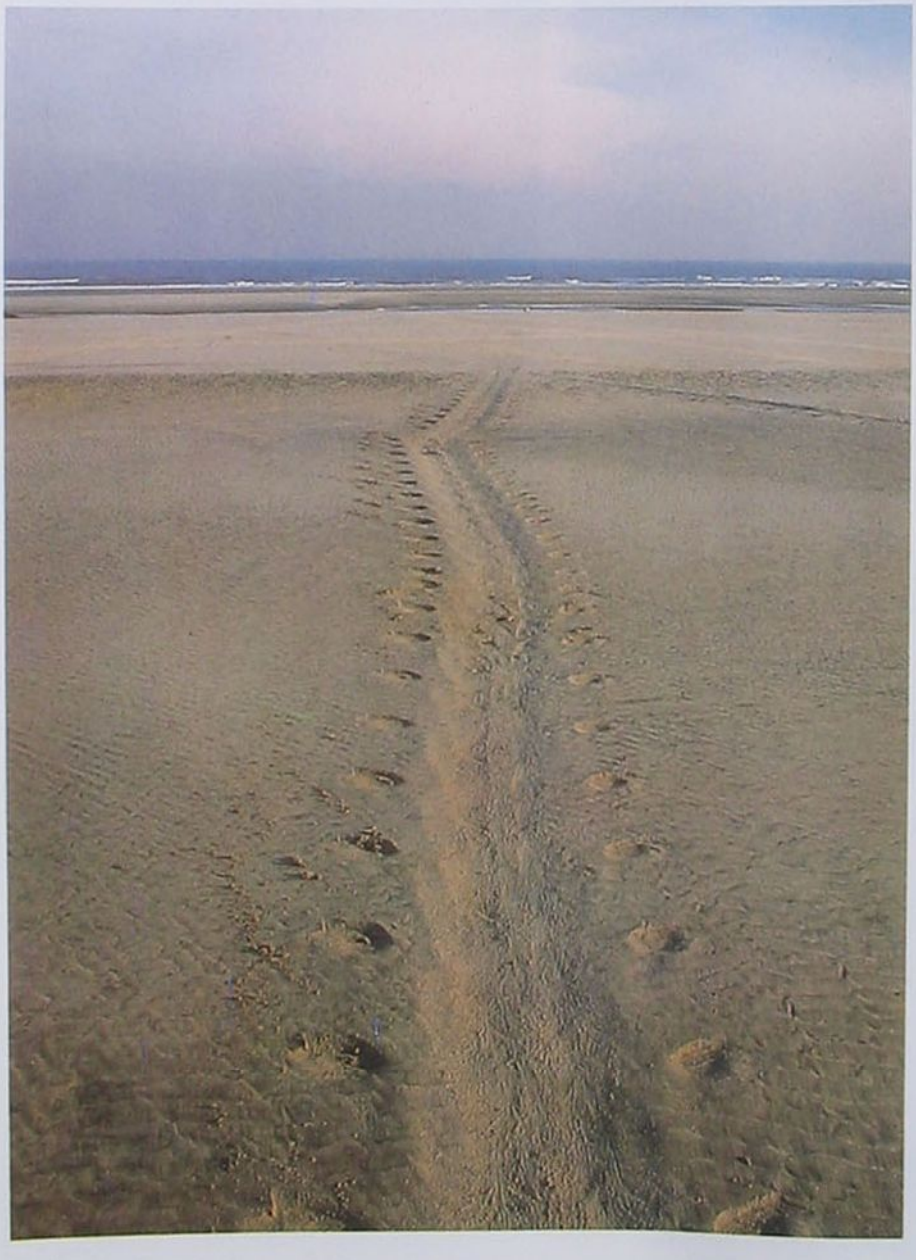
This concentration of small and medium sized mammals attracts predators such as foxes, stoats and weasels to fields and hedgerows. Stoats can sometimes be seen as they hunt at rabbit warrens, especially during summer when females are feeding young. Weasels like to hunt along regularly patrolled boundary lines and if you remain still they pass by without taking any notice. Sudden movement bothers them more than human scent, but stoats and weasels are curious and will keep reappearing to look at the observer.

Right: A badger has been by on its rounds and brushed the barbed wire as it passed beneath the fence, leaving a few tell-tale hairs behind. The chances are that it was on a regularly patrolled path.



Below right: A harvest mouse among raspberries in mid-summer. Harvest mice are more usually found among high grasses and weeds in wetlands, and of course in cereal crops.

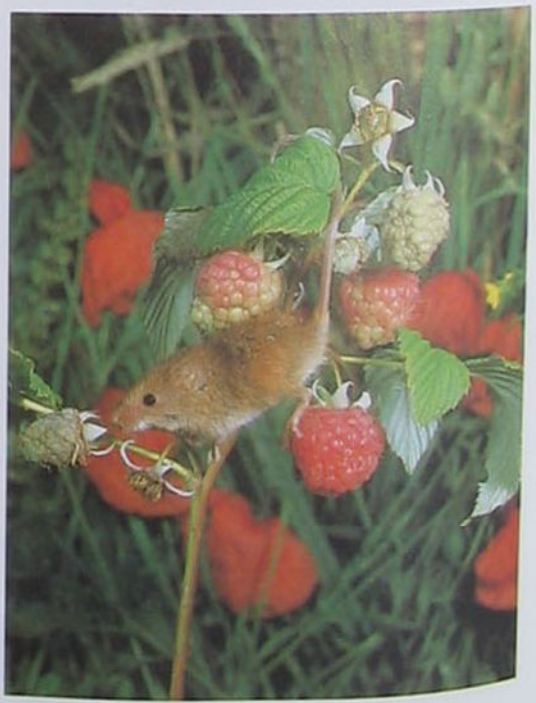
Below: The unmistakable tracks of a grey seal, on the beach at Donna Nook in north Lincolnshire.



Woodlands Much mammal activity is centred on the borders of woods where animals find cover. Walk slowly, stopping occasionally to listen: if you sense a movement, freeze and gradually turn your head towards the source: any sudden movement will cause it to vanish.

Squirrels can be surprisingly noisy if they are confident there is no danger around, dropping husks and shells to the floor as they move through the canopy. Through binoculars you can see how agile they are, hanging upside down to reach food and moving easily through trees. A pile of split nutshells or stripped pine cones on a favourite log or tree stump is a sign of their activity.

Several bat species roost in the tree canopy by day. If the wood has an old established pond, choose a warm summer evening to



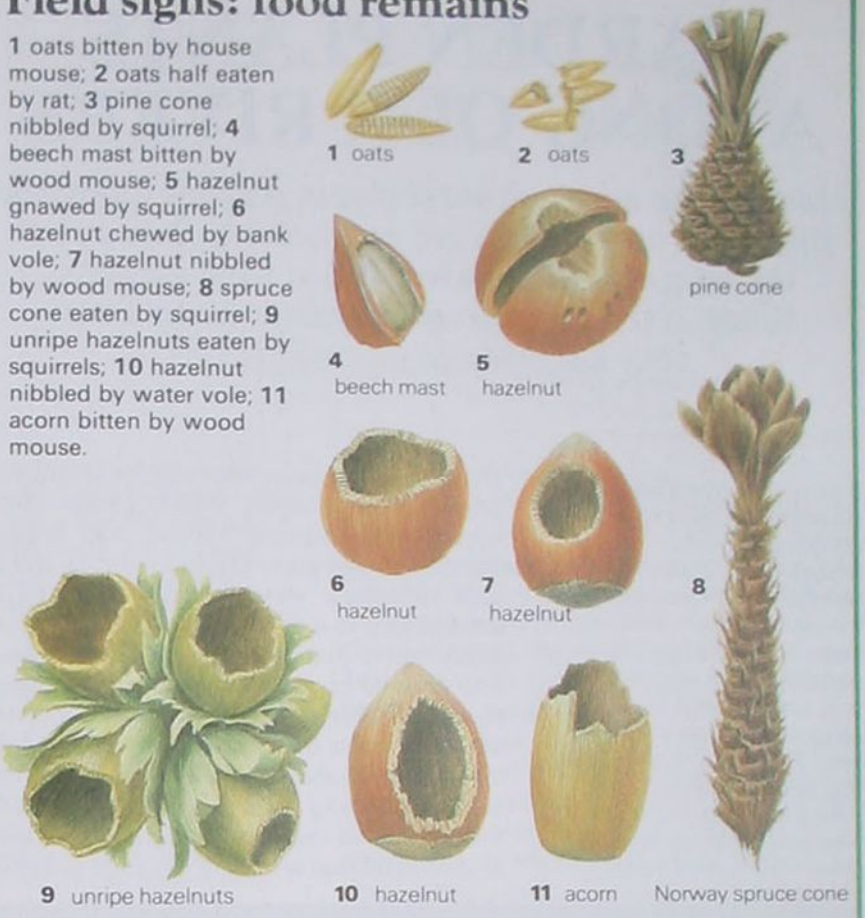
watch for bats swooping after flying insects over the surface of the water. The Daubenton's bat will sometimes settle on the surface and take off again. For the dedicated bat watcher there is an electronic hand-held 'detector' which helps identify bats by the frequency of their in-flight calls.

The small mammals–mice, voles and shrews–tend to keep to cover and any sightings are likely to be brief. Look for nests, and listen for rustling in leaf litter or foliage, or the high pitched squeak of a hunting shrew. Look also under sheets of wood or corrugated iron where they sometimes nest.

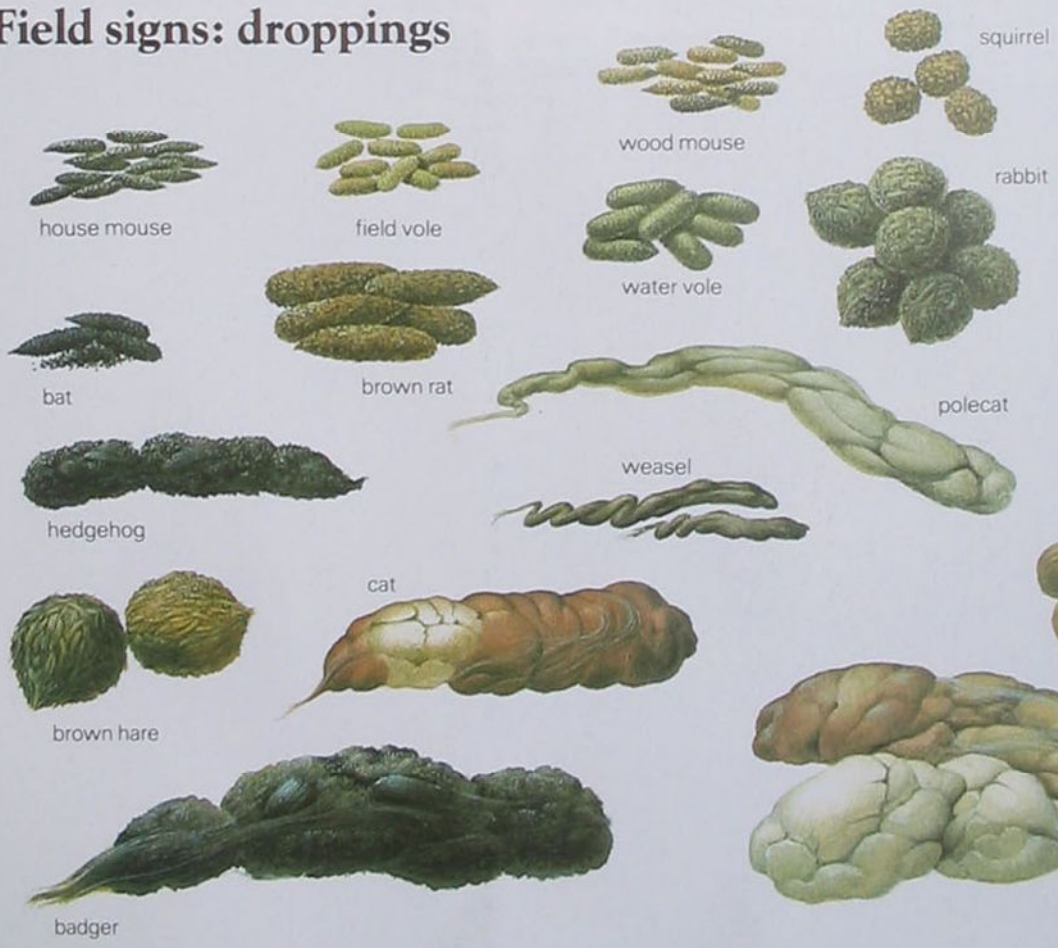
Watching badgers and foxes needs more care and patience, and is best usually at dusk. An occupied sett will have latrines nearby, containing fresh droppings. Well flattened plants and flowers along the runways to the setts are another sign, and you may well hear badgers crashing through the undergrowth. If you cannot find any signs, put some sticks across the sett entrance holes, pushing them firmly into the ground, and an emerging badger will push them aside, so next morning you can tell how many entrances are in use. Always test for wind direction as you approach a sett, making sure your scent is not being carried towards the entrance holes. Wind tends to eddy in woodlands, so try to find a watching place above ground level to make sure your scent is carried over the heads of the animals.

Field signs: food remains

1 oats bitten by house mouse; **2** oats half eaten by rat; **3** pine cone nibbled by squirrel; **4** beech mast bitten by wood mouse; **5** hazelnut gnawed by squirrel; **6** hazelnut chewed by bank vole; **7** hazelnut nibbled by wood mouse; **8** spruce cone eaten by squirrel; **9** unripe hazelnuts eaten by squirrels; **10** hazelnut nibbled by water vole; **11** acorn bitten by wood mouse.



Field signs: droppings



These droppings are typical of the species, although of course they vary in the field, depending on how old the droppings are, what the animal has been eating and how much bone the food contained. In the case of the fox, for instance, the droppings can vary more than most, because the fox's diet is so varied, containing a variety of small mammals, and fruits. Many mammals use their droppings to mark their territories.

GARDEN PLANTS ALONG OUR RIVERS

Many of the most colourful plants growing alongside our rivers and streams are not native to Britain but exotic species that have escaped from gardens. Some of these are so successful in the wild that they have ousted our own plants.

Below: One of the less common but most spectacular garden escapes is *Montbretia*, a gladiolus-like plant with deep orange, funnel-shaped flowers. In many rivers of some hillier parts of Britain it occurs only sporadically. Certain other rivers, however, have been invaded so successfully that several native plants –such as sharp flowered rush and floating sweet-grass–were driven out.

For millions of years rivers have provided an ideal pathway along which plants could successfully disperse. Indeed, the natural distributions of many plants today can still be seen to follow water courses. As well as determining to a degree the natural ranges of many native plants, rivers and streams have also allowed exotic plants to spread through the countryside and become established in the wild–a process that has accelerated over the last century as more and more foreign species are brought in to Britain for the horticultural trade. Some of these introductions have been so successful that several of the more beautiful plants, such as *Mimulus*, are almost accepted as our own, while a few have ousted some native species.

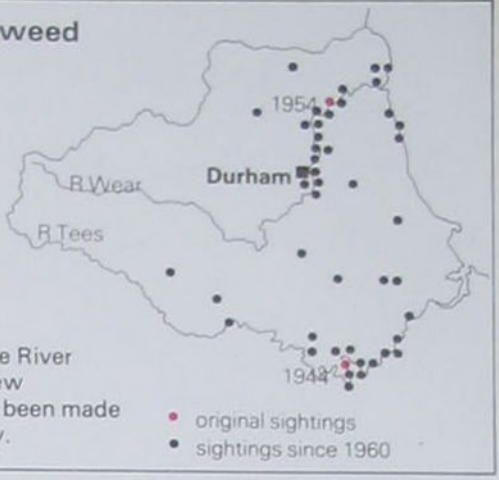
Among these 'invaders' some can be said to be truly naturalised while others have to be regarded merely as garden escapes. The distinction between the two, however, is sometimes subtle. A naturalised plant is an introduced species which finds either that the conditions in its new home are favourable to its success or that it can adapt quickly enough to its new environment. It usually reproduces freely and often spreads out to colonize new areas. Naturalised plants found in or along rivers are very rarely localised to a particular area, and most spread extremely effectively. Garden escapes, on the other hand, are usually highly localised, most species being associated with towns, villages or even solitary homesteads. Away from such human influences, garden escapes are rarely encountered along river banks.

Aquatic invaders Compared with the host of introduced species to have colonized river banks, few truly aquatic species have succeeded to the same degree. One spectacular exception, however, is Canadian pondweed.

This species is a native of North America; how it was introduced to this country is still not known. On the mainland of Britain, it first appeared in the wild in the lakes of Dunse

The spread of giant hogweed in County Durham

Until 1960, only two colonies of giant hogweed were known in County Durham–one along the River Tees, first sighted in 1944, and the other along the River Wear, sighted ten years later. Then in 1960, a colony was discovered growing alongside the River Wear in Durham. Since then, new sightings of giant hogweed have been made in many other parts of the County.



Left: Giant hogweed, with the flat, umbel-shaped head of white flowers so typical of members of the parsley family. This species is a plant to be wary of since it is covered with sharp poisonous hairs that can easily sting anyone who accidentally comes into contact with the plant. If the infected skin is then exposed to sunlight a reaction occurs and a painful blister is formed, which usually takes a very long time to heal.

Castle, Berwickshire, in August 1842. Five years later it was reported to have spread into the streams feeding the River Whiteadder and three years after that the river was choked with it, as was the River Tweed, into which the Whiteadder flows.

By 1852 Canadian pondweed had spread to a great many rivers, canals and reservoirs in Britain, causing serious flooding and navigation problems, especially in the Great Ouse catchment. The problem became so bad in the Fen District that the Government of the day appointed an official to look into the best way of counteracting the menace. Within a few years the greater pondweed had spread throughout the greater part of Europe.

After its initial domination, Canadian pondweed receded to an almost negligible level before re-invading and stabilising its present population by the beginning of this century. Since then, most other successful invaders have shown the same pattern of initial domination followed by recession and then stabilisation.

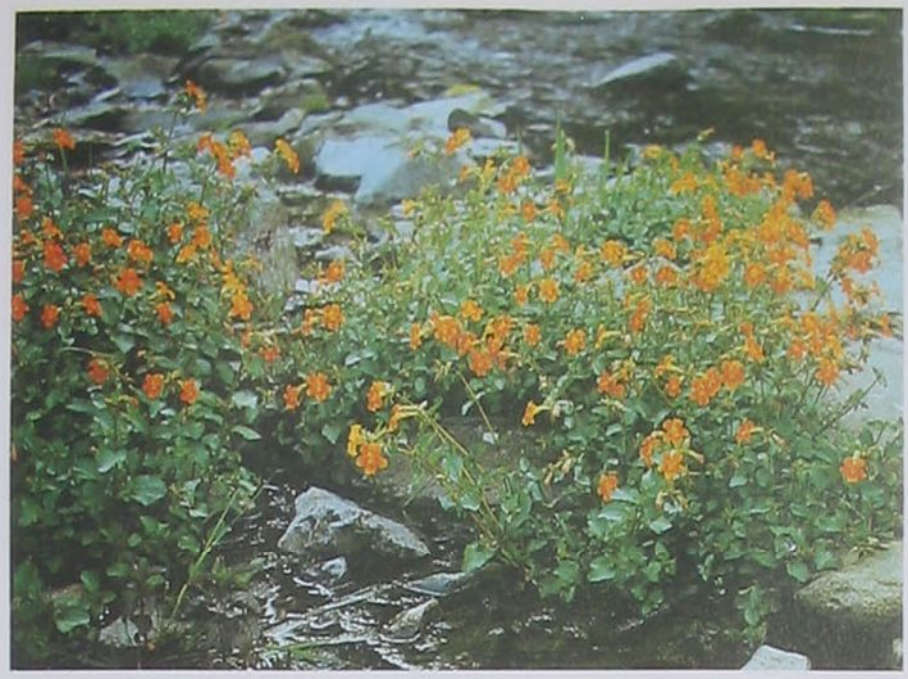
A new pondweed In the past few years a ripple of concern, tinged with an uncertain excitement, has travelled through the botanical world with the discovery in southern Britain of a close relative of Canadian pondweed, *Elodea nuttallii*. This species, too, has spread quickly, having invaded most English counties within five years. Fortunately, however, its spread has not been as rapid as that of Canadian pondweed and, because it appears to have a more limited range, it may well prove to be less troublesome.

Only a few other aquatic invaders are found in Britain. A wide range of cultivated water-lilies, for example, may be found in the wild but they never compete successfully with our native yellow water-lily. With the exception of the pondweeds, therefore, the aquatic flora of Britain's rivers remains relatively unaffected by overseas invaders.

Upland rivers Among the most colourful of our naturalised streamside plants is a group of American invaders belonging to the genus *Mimulus*. These plants are found in most upland rivers with shingle banks. There are four species, each with a characteristic distribution, and a vast range of hybrids.

At the highest altitudes the most common member of this group is a hybrid between the blood-drop emlets (*M. luteus*) and the monkey flower (*M. guttatus*). The flowers of this species are often intermediate between the blotched red and yellow ones of the former

Below: Canadian pondweed is one of the few truly aquatic plants to become naturalised in Britain.



Above: Four species of *Mimulus* have so far become established in the wild. One of the rarer species is the delicate *M. cuprens* which is common in certain parts of the Lake District and along the banks of some Pennine rivers.

Below: The River Brathay above Lake Windermere is the site of several naturalised plants, including the blue iris (shown here), the Japanese polygonum and the fern *Onoclea sensibilis*.

species and the dotted yellow flowers of the latter. Both parents may also be found in this habitat, the blood-drop emlets being common and widespread while the monkey flower is rarer but also widely distributed.

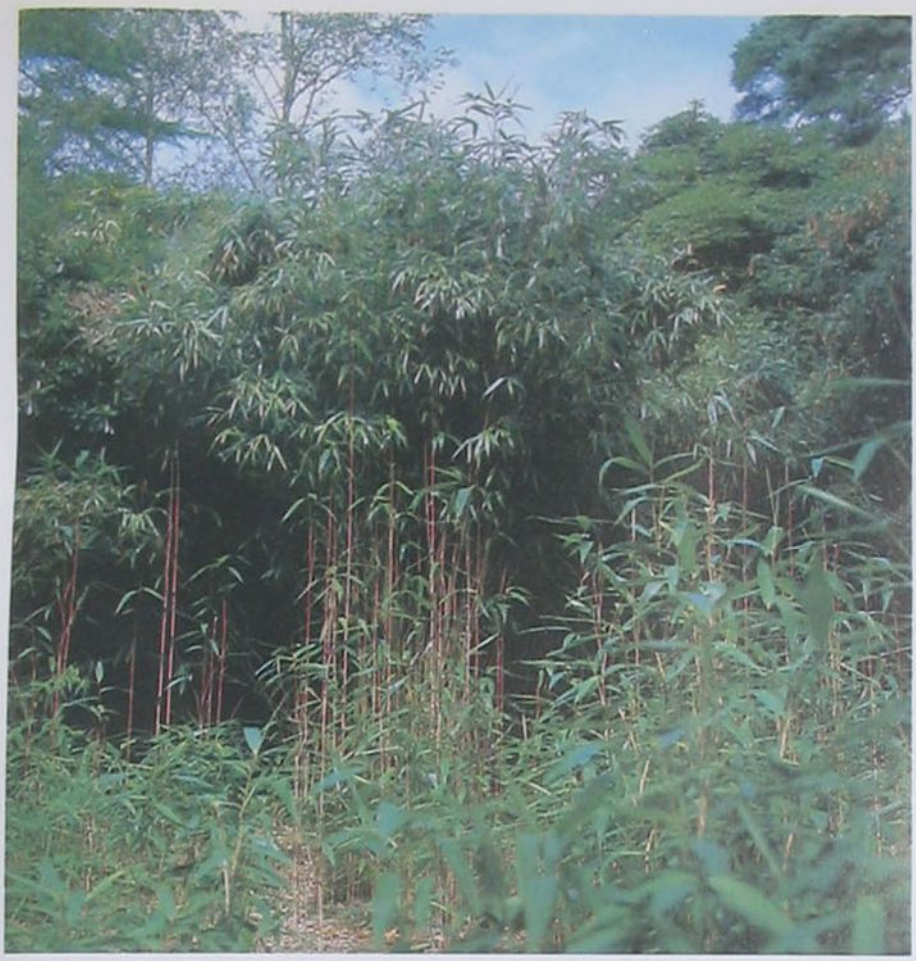
Another *Mimulus* species, musk (*M. maschatus*), is widely distributed but never common. It prefers rich soils and shaded, wooded river margins. A fourth species, *Mimulus cuprens*, is a delicate copper-coloured plant which is common in some parts of northern England.

Several other introduced plants have successfully become naturalised in wet, rocky places next to moorland rivers–New Zealand willow herb, for instance. But none has done so well as *Mimulus*. Garden escapes are also rare in upland rivers because of the sparse human population (and hence their gardens) of this habitat.

Invaders of lower reaches As fast-flowing upland rivers flow down to their flood plains their banks gain a much richer mixture of native and naturalised species. An example of a spectacularly successful invader along the lower reaches of many rivers is Indian balsam. This species is now found in most rivers in England, Wales and the middle and south of Scotland, and it is still spreading. Its success is due to its great fertility–a prerequisite for an annual plant. It also tolerates a wide range of soil types, from heavy waterlogged clays to quick-draining shingle islands. Indian balsam is a tall plant, up to 2m (6½ft) in height, with bright pink flowers.

Another continually spreading invader is the giant hogweed. It has a similar distribution to Indian balsam but it is certainly less common. It, too, is a tall plant–even taller than Indian balsam. Only rarely do specimens not attain a height of 2m (6½ft), and occasionally you can see huge plants nearly 4m (13ft) high. Apart from its height, giant hogweed looks like a typical member of the parsley family.

Three other species are commonly naturalised along fast-flowing rivers, though they have not yet reached invasive proportions. The beautiful pink flowers of the North American plant, *Montia sibirica*, are now quite plentiful along shaded stretches of many rivers. The round-leaved speedwell has also spread along many rivers, despite its inability to set viable fruits. The third species is Japanese polygonum or Japanese knotweed.



This is another large herbaceous invader which may be increasing in range and number. It produces large leaves which often form a dense cover that seems to be exploited by otters looking for protection.

Lowland garden escapes Besides the naturalised plants mentioned so far, many garden escapes have succeeded in establishing local populations along the lower reaches of fast-flowing streams. The most classical example of an isolated population is that of a species of horsetail, *Equisetum ramosissimum*, which is confined to the banks of the River Witham in Lincolnshire. It has been known to occur there for more than 30 years, yet it has not been found elsewhere in Britain.

Above: A stand of bamboo, one of the more exotic-looking garden escapes you may see along river banks.

Right: Ornamental plants are not the only ones to escape from gardens. Several species of culinary plants, such as horse radish, shown here, have also found their way out of gardens.

Below: Culinary angelica now grows along the damp margins of lowland rivers, often alongside our own native angelica.

A more typical example is the fern *Onoclea sensibilis*. This species occurs in abundance along the lower reaches of River Brathay above Lake Windermere.

Garden shrubs such as *Spiraea* are often seen growing alongside fast-flowing rivers near urban areas, while bamboo is a not uncommon sight near very grand houses. Escapes from fruit gardens may also become successfully established. Gooseberry, black currant and red currant bushes all succeed along limited stretches of river banks.

Plants of sluggish rivers No bank-side plants of slow-flowing rivers have managed to emulate the success of some of the garden escapes found along fast-flowing rivers–such as Indian balsam.

One species, sweet flag, is characteristic of a particular type of habitat–the margins of very sluggish rivers flowing over clay. It is, therefore, rarely encountered outside southern England. Within this area it can be common, for example along some stretches of the Great Ouse in Cambridgeshire and the Thames in Berkshire. Sweet flag is native to southern Asia and North America. It was introduced to Europe in 1557 and became naturalised in this country by 1660. In its habit of growth sweet flag is similar to our native flag iris, except that its crushed leaves smell of tangerines and its inflorescence consists of a mass of tiny pale yellowish-green flowers.

The presence of such a variety of naturalised plants from abroad has brought a great deal of extra colour and splendour to our river banks. Yet, the addition of more aquatic and marginal plants should not be encouraged 'willy nilly' in case they become the invaders of tomorrow and displace our own species.

Above: The large tabby moth (*Aglossa pinguinalis*). Found in June and July in barns and stables, and also in houses where it is attracted by bright lights.

Above: The meal moth (*Pyralis farinalis*). Occurs from June to August in heated warehouses, mills and wherever grain is stored.

Above: The Mediterranean flour moth (*Ephestia kuehniella*). Introduced from Continent in 19th century. Found from April to October in flour mills.

Above: The Indian meal moth (*Plodia interpunctella*), introduced in 1840s. On the wing in June and July, or all the year round in warm factories.

Above: The tobacco moth (*Ephestia elutella*). Seen from June to October, but most common in July and August. Moths remain concealed in daytime.

Above: The honey moth (*Achroia grisella*). Adults are seen flying around old beehives from June to October, and are common in England, Wales and Ireland.

PYRALID MOTHS: PESTS OF FOODSTORES

Most of the British pyralid moths occur in open countryside, but a handful of species have abandoned the leaf-eating habit, and instead exploit stored foodstuffs, hay and even beeswax. Not surprisingly, they thrive so well in these new-found environments that some have become serious pests.

Pyralids (belonging to the family Pyralidae) are small moths with narrow forewings and broad hindwings, the wing-edges usually being conspicuously fringed. The coloration of the wings varies with the species; while many are pale brown, buff or grey with a good deal of white, there are also some brightly coloured species.

More than 200 species occur in Britain, most of them inhabitants of open country where the caterpillars feed on a wide variety of low-growing plants. A few species, however, have turned to stored foodstuffs, so becoming to a large extent household species, since they occur in warehouses, food-processing factories, barns, outbuildings and occasionally untidy or neglected larders where the caterpillars feed on nuts, beans or similar goods that have been left undisturbed and accessible. Although the moths are most often encountered indoors, they are also found outdoors near buildings.

Indian meal moth One of these 'indoor' pyralid moths, the Indian meal moth, was accidentally introduced into Britain in the 1840s and is now found wherever foodstuffs are carelessly stored or processed. Its life-cycle is dominated by the surrounding temperature, which varies markedly from warehouse to warehouse.

The female Indian meal moth lays her eggs near the caterpillars' food; they hatch between two days and two weeks later, depending on temperature. The whitish caterpillars which feed on all kinds of grain, nuts, dried fruit and dried leaves, take between two weeks and two

Left: When at rest on a dark wall the meal moth spreads out its intricately patterned, chocolate, buff and white wings, and raises the tip of its abdomen. Although it is not particularly well camouflaged, it does not appear too moth-like, and may thus escape detection by sparrows searching the walls for food.

Below: The honey moth is usually associated with beehives, where the caterpillars live, feeding on wax and even dead bees. Although regarded as a pest by beekeepers, it does not pose that much of a threat to honey production, since it appears to prefer old, neglected beehives.

years to become fully grown, again depending on the temperature. They spin silken webs over the food, these and their droppings giving away their presence. The pupae are formed in cocoons in crevices in walls, and the moths hatch within a few days, although they may remain as pupae for more than a month if it is cold. The adult moths are mainly on the wing in June and July, but in a warm environment – such as a heated factory – they may occur in any month of the year.

A taste for tobacco The genus *Ephestia* contains half a dozen species, including the most serious pests of stored food products in this country. All are small, insignificant-looking moths.

The tobacco (or cocoa) moth is known to have existed in Britain for more than two hundred years. Some believe it is a native moth whose caterpillars used to feed on the dried seeds of wild grasses but switched to stored products fairly recently. The range of stored foods exploited by the caterpillars of the tobacco moth is extraordinary. Besides cocoa beans, chocolate, grain, tobacco, nuts and dried fruit, they have also been found feeding on pepper and sugar.

Flour-feeders The caterpillars of the Mediterranean flour moth are, as their name implies, essentially flour-feeders but they also feed on stored grains and dried fruit. The females lay their eggs on the floor of flour mills or on sacks containing flour. In a few days the eggs hatch and the pinkish-white caterpillars then spin elaborate silken webs among the flour. Once established, the moths are difficult to exterminate and, because of the mess created by the webs and droppings, infested sacks of flour are rendered useless. The species was not seen in Britain until the late 19th century, and there seems little doubt that it is an alien, repeatedly being reintroduced.

The meal moth looks far too attractive to be a pest, yet its caterpillars feed almost entirely on flour and other stored products in heated warehouses and mills. The moth is also occasionally seen on ships at sea, which leads to the supposition that it is a cross-channel migrant. It usually occurs in summer, and the white caterpillars take up to two years to complete their development.

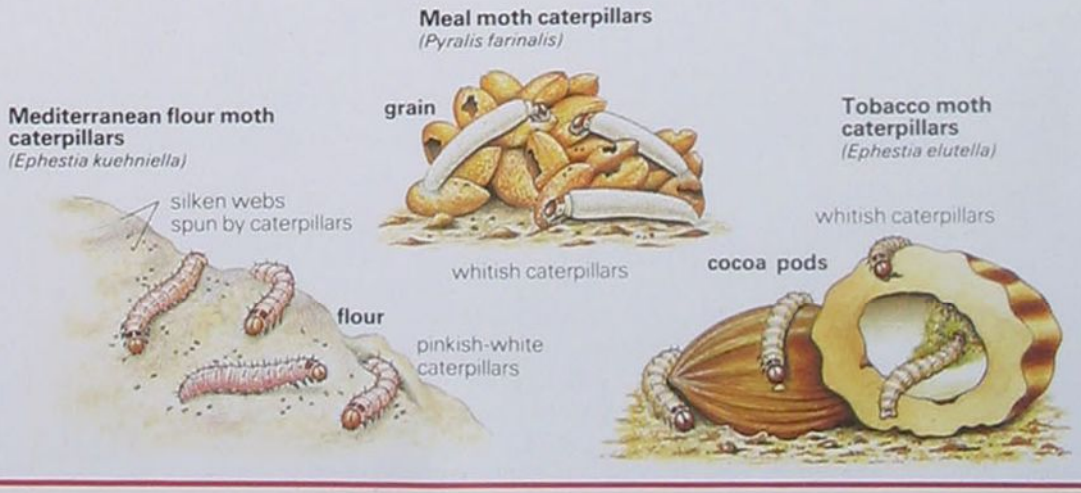
Caterpillars in the hay Less attractive and much bulkier is the large tabby moth, which commonly enters houses, attracted by their bright lights. This moth varies remarkably in size – possibly a reflection of the uncertain nature of the caterpillars' food supply, which includes seeds, seed husks and hay.

Blackish in colour, the caterpillars take about two years to develop, living in silken tubes which they decorate with pieces of waste material. The adult moth is common in June and July, particularly around barns and stables.

Honey moth The caterpillars of the honey moth, despite their name, do not actually feed on honey, but they do live in old beehives, feeding on the wax and dead bees. The adult moths occur throughout the summer and autumn, and may be seen at dusk around beehives, although it must be admitted that they are so dull-coloured and undistinguished that they are not particularly easy to see.

The pyralid caterpillars' larder

The caterpillars of the Mediterranean flour moth are essentially flour-feeders (spinning silken webs in the flour), although they eat stored grain as well – items also favoured by the meal moth's white caterpillars. The tobacco moth's caterpillars feed on a wide range of stored foods varying from dried meat to cocoa beans and tobacco – they prefer the light and medium brands.



THE REMOTE ISLAND OF UNST

Leaving aside the Shetland mainland, Unst is one of the larger of more than 100 islands that together comprise the Shetland Isles. For many people the attraction of Unst lies in its remoteness– the fact that it is the northernmost place in Britain.

Right: Fulmars–they nest in almost every suitable spot on Unst.

Opposite page: The cliffs of Herma Ness –a paradise for Unst's seabirds.

Below: It is impossible to travel on Unst without encountering the sturdy little Shetland ponies. Those seen running on the hills and moors of Shetland today are the descendants of ponies which have been present on the islands for thousands of years, but there is a certain amount of conjecture as to how they reached the islands in the first place. Traditionally the ponies were used as pack animals, particularly for bringing home peat, but now they are bred for riding and export.

Unst, which lies further north than Leningrad and Labrador, and on the same latitude as the city of Anchorage in Alaska, is about 16km (10 miles) long and 8km (5 miles) wide, but it has such an irregular and indented coastline that no part of the island is far from the sea. Although the Atlantic Ocean is on one side and the North Sea on the other, the island nevertheless enjoys–thanks to the Gulf Stream–a remarkably mild if rather windy climate.

There are great contrasts to be experienced in the atmosphere of the island. In winter violent Atlantic gales can lash the west coast and send spray over the top of the Muckle Flugga lighthouse, while in summer come the long twilights of the 'simmer dim', when nothing disturbs the calm beauty but the cries of birds and the bleating of sheep.

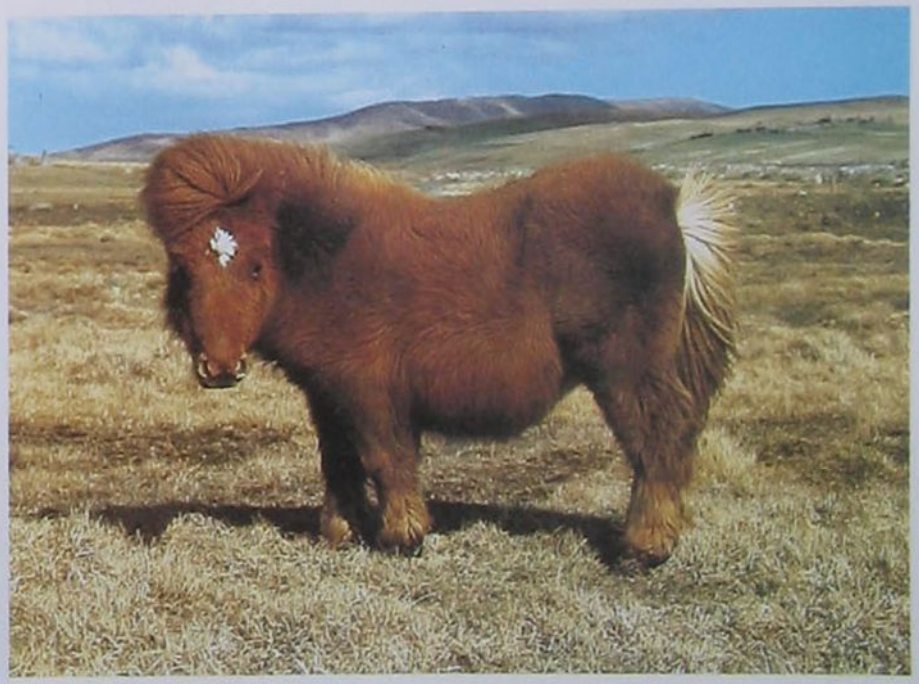
A glance at a geological map of Unst reveals a relatively simple picture. From Burra Firth (which partially divides the north end of the island) southwards from Herma Ness, the west side of the island is predominantly gneiss. Most of the eastern half is greenstone or serpentine, the latter being one of the principal rock types on Unst and extending in a broad band from near Clibberswick in the north-east to Gallow Hill in the extreme south-west. Apart from an outcrop of granite around Lamba Ness, the north-east headland around the hill of Saxa Vord is composed of schists which extend southwards in a narrowing band to a short distance south of Baltasound.

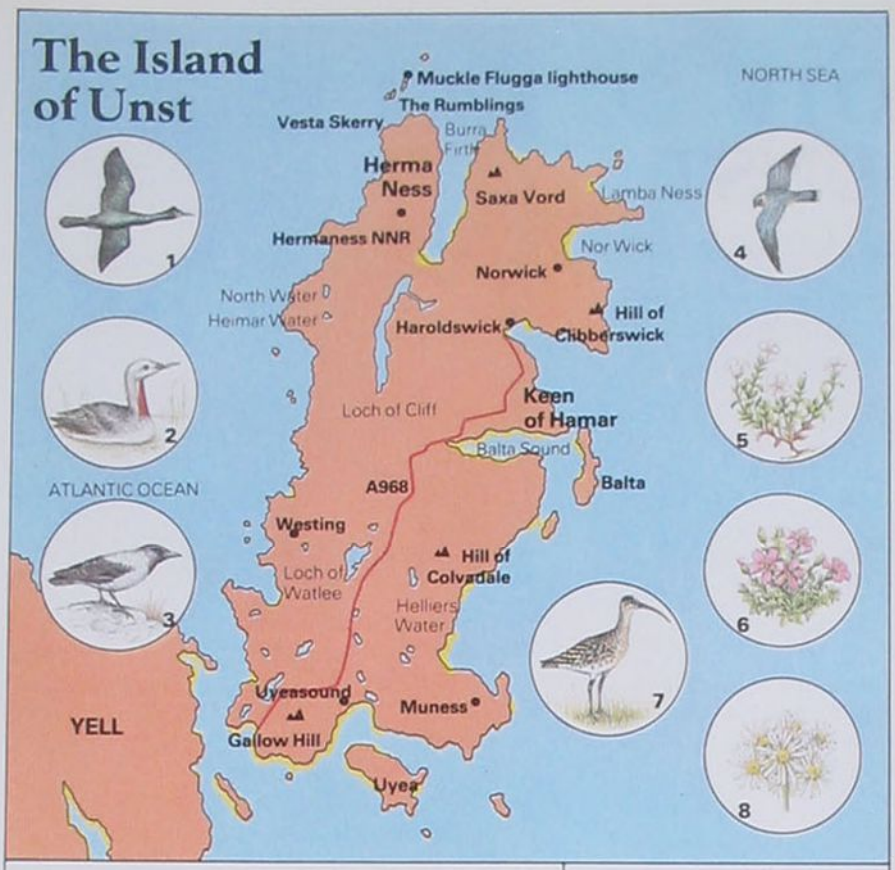
The Keen of Hamar From the natural history point of view, one of the most fascinating areas on Unst is the National Nature Reserve of the Keen of Hamar. Although attaining only 88m (289ft) above sea level, this hill has a unique combination of geological and botanical features. It supports the best-known and largest single area of serpentine fellfield habitat in the whole of Britain. On the north-west slope of the hill, stone lines or stripes can be seen–they are typical examples of solifluction (soil flowing) processes in a sub-arctic climate. It is believed by some authorities that this fellfield has persisted since the retreat of the last ice sheets.

A noticeable feature of much of the Keen of Hamar is the shattered nature of the rock and a sparse plant cover which in places can be as little as 5%. This particular habitat is known as serpentine debris and is associated with a high rate of weathering of the bedrock, and probably also with a significant nutrient imbalance since the rocks and the associated soils are poor in potassium, nitrogen and phosphorus (nutrients essential to plant growth), but rich in nickel and chromium, which are toxic to some plants.

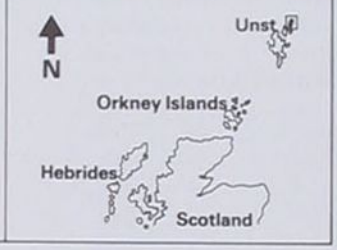
It was on the Keen of Hamar that Thomas Edmonston discovered the Shetland mouse-ear chickweed nearly 135 years ago. Other species found here include arctic sandwort, northern rock-cress and moss campion. These all have an arctic and sub-arctic distribution, and their occurrence together at such a low altitude is unique in Britain.

Other plants on Unst The sparse vegetation of much of the Keen of Hamar is not characteristic of all the serpentine areas, where the main vegetation type is in fact





Shags (**1**) nest at Herma Ness, while red-throated divers (**2**) breed on lochs inland; the hooded crow (**3**) breeds among heather on the ground, and one or two pairs of merlin (**4**) may occasionally be seen. Arctic sandwort (**5**) and moss campion (**6**) grow on the Keen of Hamar and the whimbrel (**7**) may be found among the sparse vegetation there. An alien plant—Magellan ragwort (**8**)—can be seen near the quay at Uyeasound.



grassy heath. The southern portion of the Unst serpentine supports a rich heather/bell heather community with some three dozen species of flowering plants, ferns and club-mosses, and at least 15 species of mosses and liverworts. In contrast, the gneisses and mica-schists of the western and north-western parts of the island are mostly covered with blanket peat.

Wild flowers are very much a feature of Unst. The summer visitor cannot miss the fine specimens of northern fen orchid growing on some roadside verges, while the heath spotted orchid is even more abundant and widespread. Some of the meadows around Muness are bright with a variety of wild flowers in summer, and brilliant splashes of colour are provided by the rare blood-drop emlets.

Birds of the serpentine The birdlife of Unst is perhaps of even greater interest than the plants. Here again, the serpentine areas have a special interest since it is among the short vegetation growing on them that most of the whimbrel nesting on the island are to be found—on the Hill of Colvadale south of Baltasound, for example. The whimbrel is at the southern edge of its range in Britain and 94% of the British breeding population is in the Shetland Isles.

One must go to the heather moorland of Unst to see the merlin—a much less common breeding bird species, the total population of which in Shetland barely exceeds two dozen pairs. Unst has one or two pairs of this small bird of prey, and for at least four successive years a pair bred on the same site on a steep heather slope by a small burn. Many pairs of hooded crows also nest on the ground among the heather, and suitable lochs and small pools on the moorland provide a nesting habitat for red-throated divers, which flight out to the sea to feed offshore.

The cliffs of Herma Ness The outstanding feature of Unst is the variety of its nesting seabirds. In various spots around the island you can find colonies of arctic terns, gulls and fulmars, but one locality above all the others stands out—the National Nature Reserve of Hermaness, the north-west extremity of the island. To reach the superb cliffs of Herma Ness—without doubt one of the finest seabird localities in Britain—you must walk uphill from Burrafirth and then head westwards across the blanket peat. This route has its own excitement since it is impossible to avoid the territories of hundreds of breeding pairs of great skuas (known as bonxies in Shetland)

Right: Shetland mouse-ear chickweed—one of several arctic or sub-arctic plants on Unst that are unique in Britain for growing together at such a low altitude.

Below: A common seal cow and her pup basking on a rock off the coast of Unst.

and the less abundant but even more aggressive arctic skuas.

The mobbing attacks of the skuas are a fitting prelude for what follows for, quite suddenly, you come to the cliffs and the vast expanse of the Atlantic. Just off the northern tip of Herma Ness lies the Muckle Flugga reef where the sea pounds relentlessly on the rocks below the lighthouse. The rock stacks (The Rumblings and Vesta Skerry) that form the southern end of this reef are white with nesting gannets, and more can be found on other stacks just off the main cliffs, and on the ledges of the cliffs themselves at The Neap. All told, Herma Ness supports around 7000 breeding pairs of gannets. The scene at Herma Ness is one of beauty and constant activity. Away to the south on a clear day the dome of Ronas Hill (Shetland's highest point) can be seen on the horizon, and down below the cliffs common seals dot the sea and haul out on to the rocks.

Seabirds are everywhere. Puffins by the thousand dot the grassy slopes, where their burrowing causes considerable erosion. The dominant species on the cliff ledge is undoubtedly the guillemot, some of whose colonies contain hundreds of birds. Razorbills, too, are present on the cliffs but are much less numerous. Towards the base of the cliffs are colonies of kittiwakes, the most attractive of our breeding gulls. Finally, lowest of all, are the scattered pairs of shags nesting among the great jumbles of boulders at the base of the cliffs. It is justly said that the seabird cliffs of Herma Ness are the crowning glory of Unst.

Above: You can see the comical-looking puffins by the thousand on Unst—they are possibly the most abundant bird at Herma Ness.

Right: Just behind Norwick on Unst is an area of fen and stream with many wild flowers, including the brilliantly coloured blood-drop emlets.

Below: Coastal scenery near Westing on Unst—only the cries of birds and the bleating of sheep disturb the tranquillity here.

TOADS IN SUMMER: A LIFE ON THE LAND

Above: A common toad basks in summer sunshine on a toadstool. Although common toads are usually brownish, their skin colour varies from one locality to another. This toad is a rich brick-red, matching the colour of the local soil.

Toads spend most of their adult life on land, returning to water only in the spring to mate and to spawn. Life for toads during the summer can be precarious because of their many enemies, but the toads can produce a few surprises themselves when they are faced with a predator.

Below: A mass of young common toads in a pond. Soon they will disperse to live on dry land for the summer.

As soon as spawning is completed in spring, toads leave their aquatic habitat to spend the summer on land. The common toad's breeding season ends in late May, while that of the natterjack continues until early June. From then until the end of hibernation, early the following year, toads are terrestrial animals.

Skin care All through the summer toads tend to be more active at night than during the day. Being cold-blooded, however, they also sit out in the bright sunshine of a summer's day, in order to obtain extra bodily warmth. They can do this for short periods, say a few minutes at a time, but if they bask for any longer their bodies begin to overheat: if this continues for too long, the animals die. To prevent overheating, toads have moist skins, and the constant evaporation of water from their skins cools them down. Toads control their body temperature by keeping a balance

between the cooling effect of evaporation and the warmth that comes directly or indirectly from the sun.

Toads have various methods of keeping their skins moist. Although land-based, they remain near water so that they can take a short dip, as well as drink, from time to time. They have numerous glands beneath the skin which secrete a mucus that keeps the skin moist in between dips. Toads also shed their skins several times during the summer, and one effect of this is to maintain the skin in good condition. Although only a thin, transparent layer is shed, you can sometimes see parts of the cast skin glistening among the dew on the grass on a cool summer's morning.

If the summer is particularly dry and hot, toads sometimes bury themselves in loose, sandy soil in an attempt to avoid excess water loss. Common toads are remarkably good at burrowing, and can bury themselves very fast: their strong, long legs are highly useful for this task. The toads lie buried and sheltered from the sun, conserving moisture until conditions become a little cooler–for example, when night falls.

Daily routines For certain periods during the summer, the activity of toads during both day and night is very predictable. For some weeks at a time, an individual toad feeds in the same place each night (unless prevented by extreme weather conditions) and hides in the same place by day. After maintaining this pattern of activity for a few weeks, the toad then selects a new feeding place. Toads seem to have no difficulty in locating favourite feeding places each night, then returning to the safety of their daytime refuges.

Above: These natterjacks were photographed in the south-west of Ireland. The stone under which they were hiding has been lifted, suddenly exposing the toads, but their skin colour still serves to camouflage them. Not only is the colour well matched, but the warty, granular texture of the skin also resembles that of the soil.

Natterjack toads are somewhat unusual among toads and frogs in general in that rather than hopping or crawling they tend to run. They are capable of running in short bursts, thus covering a large area while at the same time looking about for food. Natterjacks feed on a variety of small creatures including spiders, insects (especially beetles) and worms. Common toads are reputed to eat almost any small animal as long as it moves. They have been known to eat earthworms, insects, spiders and also nestling mice; sometimes they even take the young of slow-worms and snakes.

Defence systems Toads fall victim to many kinds of predators throughout the summer. Small mammals such as hedgehogs and stoats prey on toads, as do many species of birds, including gulls and blackbirds. Snakes also feed on toads. Although they appear defenceless, toads protect themselves by means of their poison glands and also by some interesting and unusual forms of behaviour.

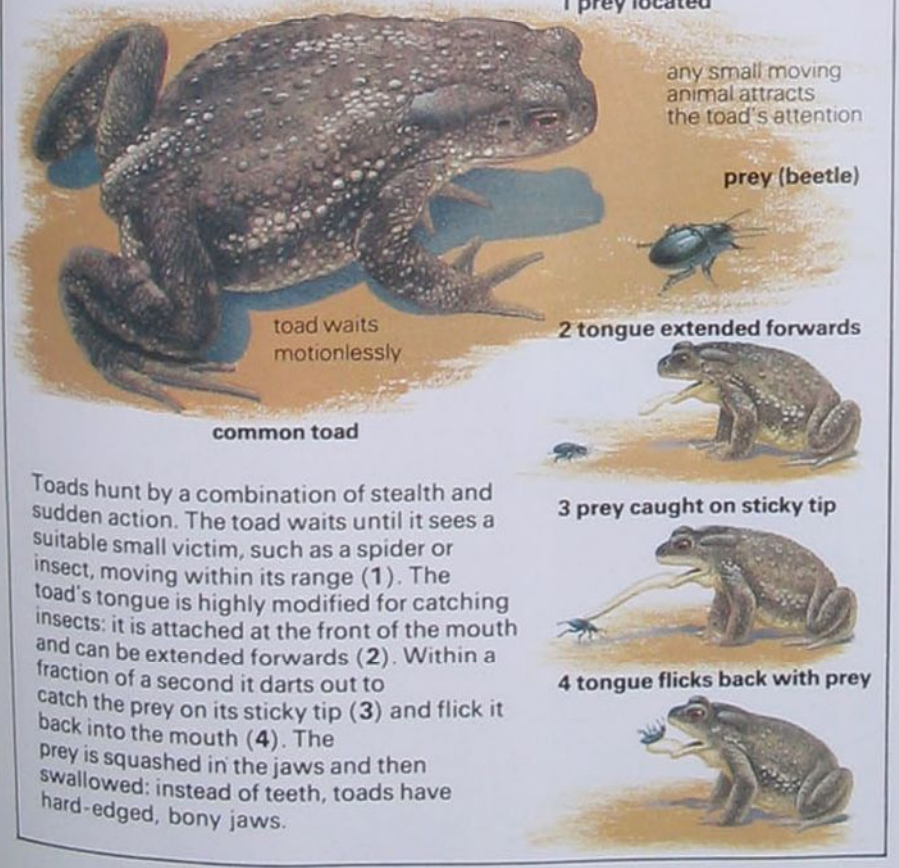
Situated on either side of the toad's body, just behind the eyes, are the paratoid glands. These can be seen clearly as pale oblong bulges, and they produce a secretion which is mildly poisonous to the toad's enemies. Usually it does little harm other than causing an inflammation of the skin, but this is sufficient to deter predators.

If you are handling a toad, therefore, do so with care, for if roughly treated the animal may secrete its poison, and this may give you a skin inflammation.

When toads are alarmed, if approached by a predator for example, they sometimes inflate themselves so as to appear as large as possible. A very rounded and fat toad with legs stiffly outstretched and head lowered can be a strange and intimidating sight for the attacking animal, causing it to withdraw.

Where toads are found The common toad

How toads catch their prey


1 prey located
any small moving animal attracts the toad's attention
prey (beetle)
toad waits motionlessly
2 tongue extended forwards
3 prey caught on sticky tip
4 tongue flicks back with prey

common toad

Toads hunt by a combination of stealth and sudden action. The toad waits until it sees a suitable small victim, such as a spider or insect, moving within its range (**1**). The toad's tongue is highly modified for catching insects: it is attached at the front of the mouth and can be extended forwards (**2**). Within a fraction of a second it darts out to catch the prey on its sticky tip (**3**) and flick it back into the mouth (**4**). The prey is squashed in the jaws and then swallowed: instead of teeth, toads have hard-edged, bony jaws.

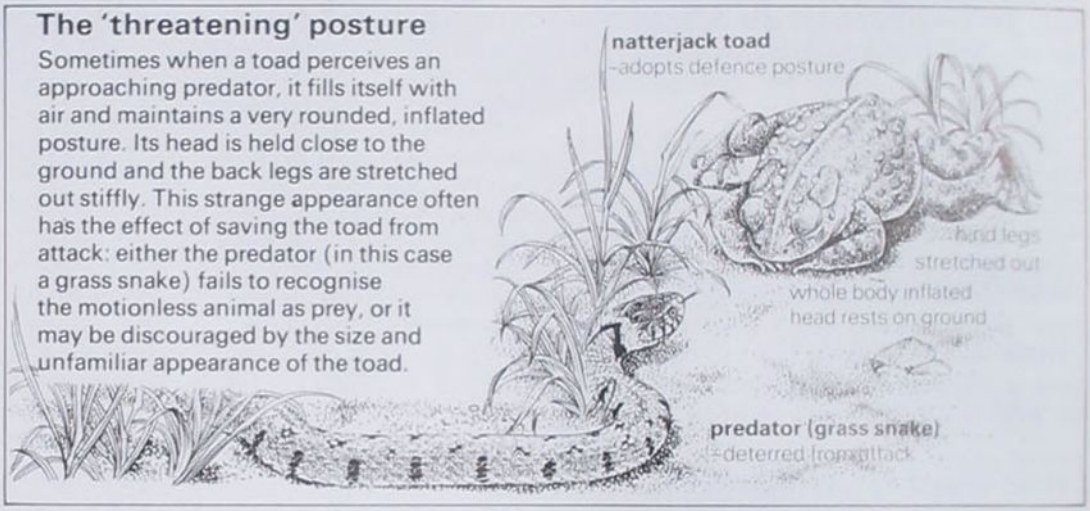
Above: A natterjack crouches on the trunk of a fallen birch tree. In this raised position it is relatively safe from predators. This natterjack derives additional safety from the perfect match of its skin colouring with that of the birch bark.

has a very widespread distribution, being found throughout most of Europe. It occurs in England, Scotland and Wales, but strangely not in Ireland. At the end of summer, when common toads seek overwintering sites, they sometimes hide in rather unusual places, including cellars and greenhouses; and they have even been found in bags of potatoes.

The distribution of the natterjack toad includes western, central and northern Europe, where in most cases its habitat consists of sand dunes and other areas close to the seashore. Some populations seem tolerant of salt water, or at least brackish water. The natterjack's present distribution in Britain has been the cause of considerable concern, and it is now believed that this toad is in danger of extinction. It has been recorded in south-west Ireland, north Wales, on the west coast of southern Scotland, and in Dorset, Hampshire, East Anglia, Merseyside and Cumbria in England.

The 'threatening' posture

Sometimes when a toad perceives an approaching predator, it fills itself with air and maintains a very rounded, inflated posture. Its head is held close to the ground and the back legs are stretched out stiffly. This strange appearance often has the effect of saving the toad from attack: either the predator (in this case a grass snake) fails to recognise the motionless animal as prey, or it may be discouraged by the size and unfamiliar appearance of the toad.



Below: A natterjack calling in the breeding season: the display posture resembles the 'threatening' posture seen in summer.

Populations of the natterjack have undergone dramatic decline in recent decades, particularly in southern and eastern England. In contrast, the south-west Scottish population seems to be thriving. There is no doubt, however, that the natterjack toad is now very rare; because of this, and because the few remaining populations are geographically isolated, the species is fully protected by the law. It is an offence to collect, injure, kill or sell natterjack toads.

The natterjack's decline seems to result from a combination of factors. Fewer and fewer suitable breeding sites are available to the species. Like the common toad, it is best suited to breeding in old and undisturbed ponds, but many of these have now been destroyed, particularly in coastal areas where there has been considerable drainage and alteration of land use. It also appears that the common toad competes with the natterjack both for food and habitats. The common toad generally starts breeding before the natterjack, and where the two species share the same habitat it is not unknown for the tadpoles of the common toad to eat natterjack tadpoles thus eliminating their competitors.

The insects easily visible in the countryside represent only a fraction of the numbers actually there. An eye for detail and special equipment are needed to find them.

If you search in woods, along hedgerows, in the meadows, or on any area of wasteland, you may find butterflies, bees, grasshoppers and many other insects. By disturbing the leaf-litter on the woodland floor you can observe other small creatures, such as woodlice, beetles, mites and spiders, scuttling away to escape the disruption of their dark world, and if you go out at night with a torch you can watch many other invertebrates in their nocturnal wanderings – harvestmen, ground beetles and their larvae, and night-flying moths.

These are animals you can see without much trouble. Yet there are many more to discover by using the special, yet simple, apparatus available to the modern naturalist, and by adopting a few methods of observation. Although this equipment is on sale in certain stores, most of it is easily constructed at home.

Trapping with nets Flying insects are caught with a kite or butterfly net. It has a lightweight bag made of green or black mosquito netting (or a similar soft material), and is long enough to fold over on itself when the insect is caught. The net frame should be constructed of light metal and can be jointed so that it folds up. Wave the net towards the approaching insect to trap it and then, once it is caught, fold the net over so that it cannot escape.

If an insect settles on the ground or on a bramble bush, you can catch it as it flies off in response to your approaching net; again, flourish the net rapidly towards but not on top of the insect. Warm, dry weather is best for this exercise.

Another type of net, the sweep net, is designed to catch insects and spiders on such

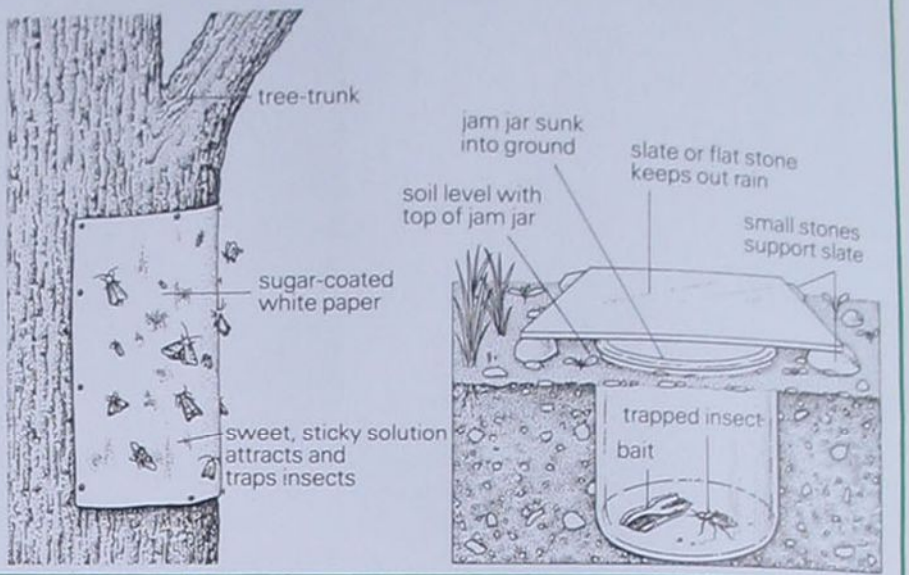
Above: If you place some decaying fruit out-of-doors, you can watch insects feeding. Red admirals are partial to rotten apples.

Below: The kite net or butterfly net is used to catch flying insects. When you can see an insect flying within reach, flourish the net towards it, and then once it is inside, fold the bag over on itself so the insect cannot escape. If you make your own kite net, ensure that the net is long enough to fold over.

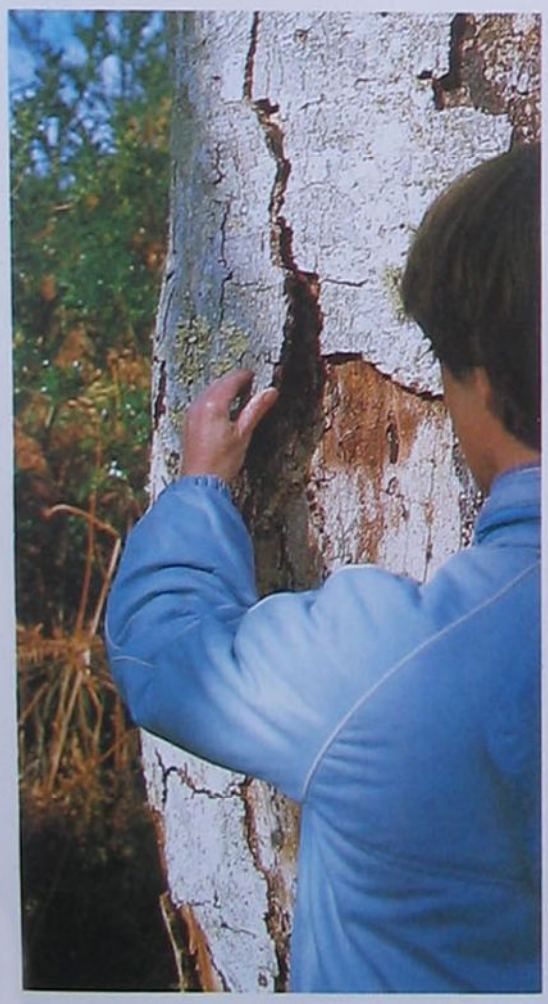
Nocturnal insect traps

An effective way of catching night-flying insects is to pin a sheet of sugar-coated paper on to a tree-trunk or gatepost. The sticky sugar mixture, made with treacle or brown sugar (thickened by gentle heating) and a little rum (added when the mixture is cool), attracts night-flying moths and beetles, which then become drunk on the solution. Examine your tree-trunk after dark.

The pitfall trap is used for catching nocturnal ground-dwelling invertebrates. Sink a jam jar or tin in the ground, ensuring the soil is level with the top of the jar, and place a flat slate, supported by four smaller stones, over the jar to prevent the rain entering. You can bait the trap with almost anything – meat, vegetables, bread. Inspect your catches in the morning, and then release them.



vegetation as long grass and beds of nettles. A strong metal frame, preferably triangular and which folds up when not in use, carries a fairly short net bag of nylon or other hard-wearing material. Sweep this net to and fro over the vegetation so that the insects are jarred off the plants; after about six sweeps examine the contents of the bag. It may include bush crickets, red admiral caterpillars and small tortoiseshell caterpillars.



Below left: Searching under the bark on a tree can reveal a wide range of insects: bark beetles, booklice, earwigs, larvae and hibernating wasps. A large hand lens, similar to the kind used for map-reading, is useful for examining smaller species.

Below: Many small creatures make their homes among the leaf-litter on the woodland floor. A garden sieve of about 1sq cm mesh is suitable for finding these insects. Although you can sieve the leaf-litter in the wood it is more effective if you collect a sample in a plastic sack and take it home. Here you can sieve it on to a white sheet – preferably indoors as the warmer temperatures activate the insects.

The beating tray If you hold an open, inverted umbrella under a tree (an oak tree is particularly rewarding) or bush and shake the branches vigorously, or give them a few short taps with a stick, you have a ready-made beating tray – the insects fall on to the tray and you can then observe them more closely. (Specially made trays are of black or green nylon – white glares too much in the sun – on a folding frame.)

Twigs, leaves and other bits and pieces fall into the tray, but wait and watch for a while – there may be some stick caterpillars or other camouflaged creatures which at first feign death (catalepsy) but usually get up and walk away later. You can make some interesting comparisons of the fauna in different trees using this method.

Simple equipment Perhaps the most useful apparatus in the field is a sharp pair of eyes. Lift up logs and boulders and search under them, but put them back in the same position so as not to destroy the habitat. Separate the base of a tuft of grass or other vegetation (a plastic bag to kneel on is useful), and tease earwigs and mites out of tree-holes on to a white plastic sheet.

Left: A beating tray for catching insects shaken from trees. For amateurs, an inverted green or black umbrella is as effective.

Remember that scavengers such as dung beetles and burying beetles occur in some strange places; look in rotting carcases, use a chisel to examine cow-pats or dig out one of the holes marked by a small pile of earth on sandy ground – you may find a large black dor beetle at the bottom of the burrow. The carcases of many animals attract a number of large black and orange burying beetles, as well as flies whose larvae eat the rotting flesh.

Some insects are associated with specific kinds of plants – for instance certain aphids are found on rose bushes and one species of leaf-hopper occurs on rhododendrons. It is well worth while searching on these.

In the same way, parasites of mammals and birds have their own particular hosts; for instance rabbits, squirrels and badgers have their own kind of flea, and many lice are specific to the birds on which they occur. If you find a small mammal or bird which has recently died, put it in a plastic bag (handle it with tongs) and tie the top firmly. Although various fumigants can be used to dislodge the parasites, it is usually sufficient just to leave the contents for a while until the insects fall off and accumulate in the bottom of the bag.

Attracting insects with light Many night-flying insects are attracted by light, especially the ultra-violet end of the spectrum. Special mercury vapour bulbs giving off ultra-violet rays and traps running off mains electricity or a generator are obtainable, but they are expensive and dark glasses must be worn as ultra-violet light is harmful to the eyes.

However, a home-made light attractant is nearly as effective. Spread a white sheet on the ground and hang it between two poles in such a way that light cast on it from a good paraffin pressure lamp, or other source, is reflected. If mains electricity is available, a 200 watt bulb is ideal. You can usually attract moths, a number of ophion ichneumon flies, night-flying beetles (including water beetles), and even water bugs flying from pond to pond.

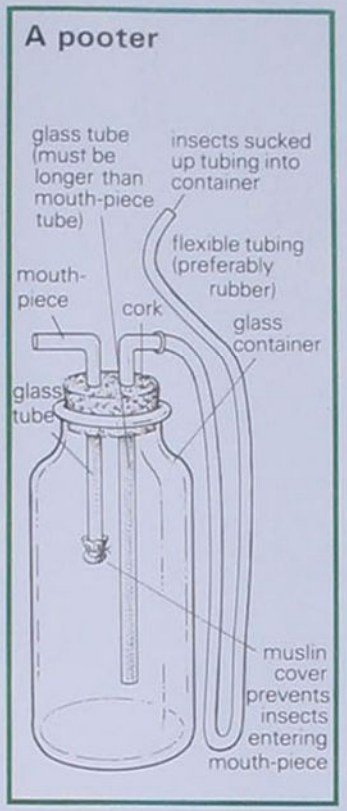
Transfer the insects which settle on the sheet into a pooter (see illustration) if you wish to observe them more closely, or you may be able to coax them into a container. In the morning the captives must be released into bushes so the birds do not find them.

The best time to set up this trap is when flight conditions are good; a still, warm, moist evening – the kind of weather that precedes a thunder storm – is best, while a cool moon-lit or windy evening rarely yields successful results.

Teasing out soil-dwellers A large number of insects and their larvae live in the soil. Dig out soil samples at different depths, for instance every 10cm (4in), and then place each soil sample in a separate bowl of cold water. Most of the creatures will float to the water surface, so pick them off with a small paint brush, taking care not to damage them.

Look carefully at the residue on the bottom of the bowl for larger insects as you pour away the water, or wash the material through a fine sieve to be certain you have not missed anything. Take particular care to look for small mites and springtails which usually abound in soil. The invertebrates in the different soils (sands, clays and chalk, as well as garden and cultivated soils) can be interestingly compared by this method.

The conservation aspect There are obviously many other ways of trapping insects and extracting them from their habitats. Remember that unless a sample is needed for serious study, the captives must be released in the same place, ensuring they are not too exposed to predators. Just catch a small number for observation. Kill the absolute minimum, and then only when there are reasonable numbers.



Above: A pooter, easily constructed at home, is used for transferring insects – without damaging them – from a beating tray, white sheet or sweep net into a container, where you can examine them more closely. Place the end of the flexible rubber tubing near the insect, and then suck through the mouth-piece, thus drawing the insect into the container.

Stockists

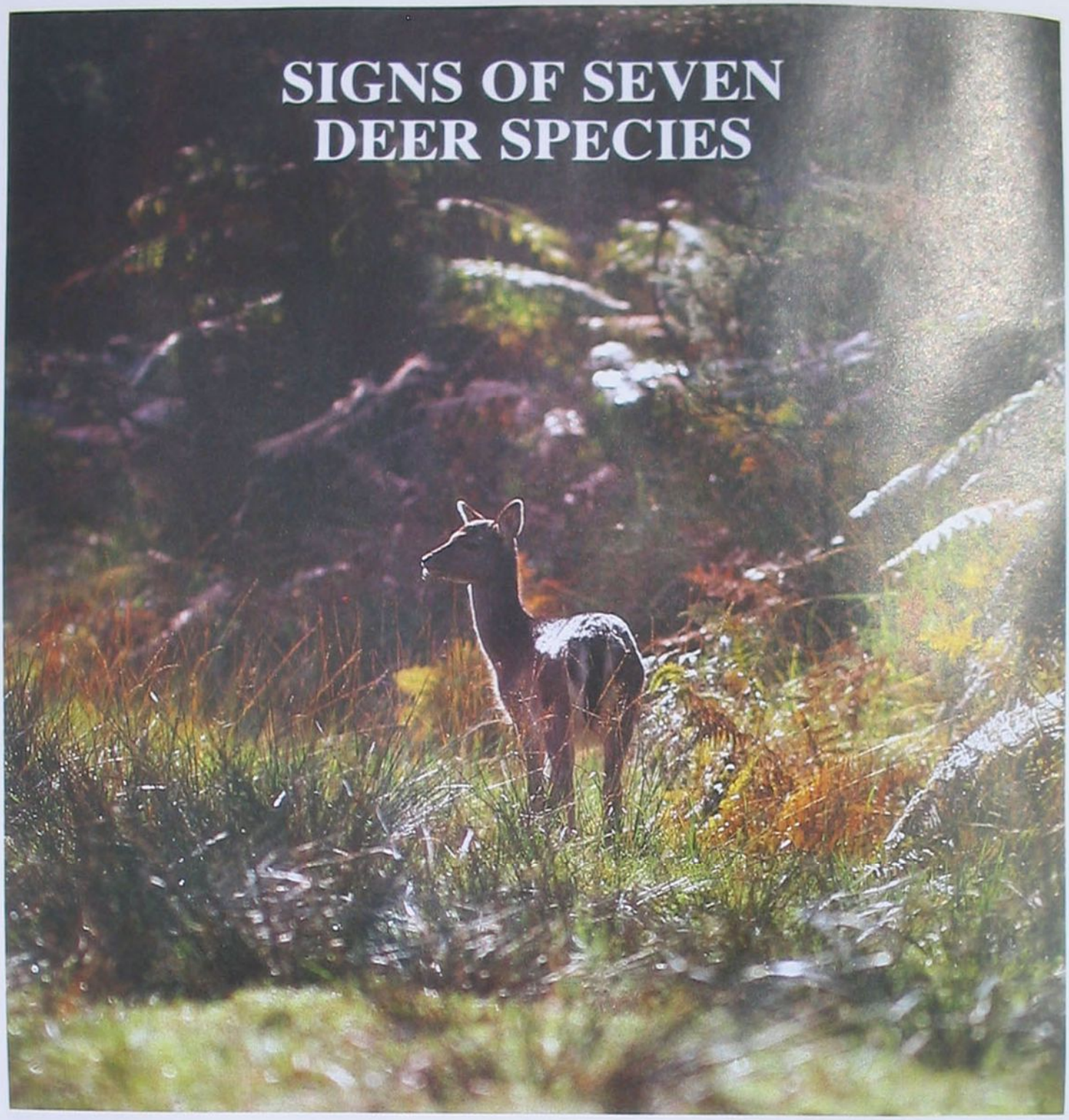
Watkins and Doncaster, Four Throws, Hawkhurst, Kent. Tel: Hawkhurst 3133/4.

Philip Harris Biological Ltd, Old Mixon Industrial Estate, Weston-super-Mare, Avon. Tel: Weston-super-Mare 413063.

Griffin and George, Gerrard Biological Centre, East Preston, Sussex. Tel: Rustington 72071.

Right: The sweep net, designed to catch insects and spiders in such vegetation as tall grass and nettles, is swept horizontally to and fro across the plants.

SIGNS OF SEVEN DEER SPECIES



Deer–used by man for food and sport–have been studied for centuries so much is known of their behaviour and the best ways of getting close to them.

There are seven species of wild-living deer in the British Isles but only the red and roe deer are native. The fallow deer was probably introduced from Asia Minor by the Romans, and the other species–the sika deer, Chinese water deer, muntjac and reindeer–have been introduced at various times during the past 300 years.

Deer are mainly social animals, living in groups or herds. They are active at dawn and dusk, coming into the open from mainly woodland retreats to feed on grasses, shoots, leaves, berries, root crops and cereals. Like cattle and sheep, deer are ruminants, regurgitating their herbivorous diet and chewing the cud.

Male deer–known as bucks or stags depending on the species–have antlers which are grown before the rut each year and then shed. Of the female deer, only the reindeer has antlers. The breeding season usually begins in early autumn and the young are born to coincide with the best feeding time

Above: A young fallow deer. Fallow deer are widely distributed in parks and woodland areas throughout the British Isles. Like red deer, they are highly attached to traditional rutting stands and will return to them year after year. Many feral herds also exist, formed from escaped park animals.
The best way to watch deer is to stalk them or to wait for them in a high seat or hide. Dawn and dusk are the ideal times.

for the mother–the summer of the following year. The muntjac is an exception–it breeds throughout the year.

Watching techniques There are two basic ways of observing deer at close range: either by stalking them on foot to try to get closer, or by waiting in a hide or high seat for the deer to come to you. As with all mammal watching, wear drab, waterproof clothes, preferably brown or green. Wellingtons are suitable in woodland, but for stalking deer on hills stout walking boots are more comfortable. At close or medium distance deer can be watched with binoculars, but for long range viewing–possibly of highland deer a mile or so away–a telescope is useful.

Deer parks are the easiest places to see deer at close quarters. These deer–usually red, sika and fallow–are used to public gaze and may allow a close approach on foot. Don't attempt this in the breeding season as you may provoke an attack from an irate stag or buck. At this time of year, or with shyer park deer, watching is best done from a vehicle. Even wild deer, which can sometimes be observed from roadsides as they feed, do not associate a vehicle with danger, but will soon disappear if you open a door or leave the car.

Deer that live in woodland, such as the roe, are best watched from a high seat or hide near their regularly used runways or feeding areas. Hides can be purchased, or constructed from canvas or tarpaulin draped over a wooden framework and anchored with cord or twine. Purchased hides are not very durable and should not be left in the open for too long.

There are several drawbacks to hides: they tend to concentrate human scent in one place, vision is limited, and sitting in a small canvas box for long periods can be uncomfortable. In well visited areas hides can attract the attention of vandals. It is better to use hides on undisturbed private property, or take advantage of natural hides such as trees, rocks or ruined buildings–objects with which the deer are already familiar.

A better method of remaining undetected is to make a high seat. These can be bought, but a far cheaper method is to fit a wooden platform securely to the branches of a tree, several feet above the ground. The platform can be reached by a ladder, and it gives an unrestricted view, keeping your scent well above the animals. It is also above their line of vision and any noise at that height is unlikely to frighten them.

Stalking Getting close to deer by stalking is more of a challenge, and a greater sense of achievement is felt if you can approach, then leave, without being spotted. Deer have excellent sight and hearing, and an acute sense of smell. To avoid detection needs care and a little forward planning. Always keep downwind. Test the direction of the wind at every opportunity by throwing grass or crumpled dry leaves into the air, or by holding up a handkerchief (out of sight of the deer). Remember that in woodland wind tends to eddy and a freak current of air may take your scent to the deer.

If you know where the animals are congregating, perhaps at a feeding area or rutting ground, approach quietly, using cover and stepping carefully to avoid cracking twigs or fallen branches. During the breeding season, the sound of the bellowing stags or bucks will help you locate the rutting area. The males will be concerned with herding the females, but look out for the does or hinds, especially one that may be a little way from the main group but is still very much on the alert.

Above: These branches have been cut down to help the deer feed in winter; a spot like this is a good place to wait to see deer.

Below: A family party of sika deer. This species is mainly found in thick woodland with dense undergrowth, and sometimes in marshy areas. The New Forest is an ideal place to watch the rut in September and October.

If you see a group of deer in the trees, continue to walk and allow them to see you. Do not stop when you first notice the animals – if they have spotted you they will quickly move into cover. When you are well out of their sight and smell, test the wind direction and then double back and approach the deer carefully.

Stalking away from the cover of woodland is more difficult and you must be prepared to get down on your knees or stomach and to crawl for long distances. Red deer, especially, are a challenge to the stalker, for during summer they spend much time high in the hills on exposed terrain. When you first spot the deer, and before they have detected you, get out of sight and test the wind direction. If the deer are a long way off and the wind is not in your favour, you may have a great detour to make before a safe approach is possible.

Deer can spot a figure silhouetted against the skyline at great distances, so only walk upright if the contours of the land allow you to remain hidden. When cover is lost and you have to move over open ground, lie flat on your stomach and only move when all the deer have their heads down. Freeze when a head is raised or a deer looks towards you. The stalk will end when you are close enough to have a good look through binoculars, or if the deer spots you, or if you run out of cover and any further movement will give you away.

Female deer are most easily watched when they have young calves or fawns. A doe or hind will not move far from her offspring lying in cover, and if she barks a warning and runs round in circles you can be fairly sure of being near the hiding place. Never handle a young deer, even if you think it has been abandoned. In all likelihood the mother is nearby and will return when you have gone. Although a handled deer is unlikely to be rejected by its mother because of human scent on its body, overhandling may cause it to leave cover and try to follow you.

Looking for signs You can learn about the habits and behaviour of deer before you begin watching them by studying the signs they leave in their territory. The regular runways or paths are most obvious in woodland where the deer have been moving through thick cover, or during snow. You will see droppings and tracks – they vary enormously with species, age and weathering, and you may be able to detect the musky smell of scent deposited by the males on trees and bushes during the breeding season. At this time of year, too, the males make scrapes with their forehoofs at the base of trees and beside bushes and other landmarks, and thresh young trees and tall plants with their antlers. Roe deer make rings around a stone, tree stump or small tree or bush during their rut in July and August. The rings are usually circular, sometimes a figure of eight, and are formed when the buck chases the doe prior to mating.

During the rut you may also find a fresh wallow, a wet or muddy depression where red

Above: A roe deer buck which is shedding its winter coat. Roe bucks lose their antlers in late autumn. The rut is in mid-summer and because of delayed implantation the young are not born until the following April-July. Roe deer are inquisitive and can sometimes be called closer by using a lure to simulate the cry of a fawn. A squeaky toy sometimes does the trick.

Below right: Red deer damage to trees may be as high as 3m (10ft).

Below: A cast antler which has been chewed by deer for its calcium. The antlers of fallow deer are the most commonly found.

deer stags have been rolling to enhance their scent. These wallows are used by both sexes at other times to help rid the animals of their old winter coat. Traces of hair may be found around wallows in late spring. At the end of the breeding season male deer shed their antlers, which are mostly eaten by the deer and provide a valuable source of calcium for the expectant females. Newly formed antlers are covered in thin skin or 'velvet' which is removed by being scraped on vegetation. This is known as fraying and young trees used for this purpose, worn and damaged about two feet above the ground, may have traces of velvet attached. More serious tree damage is caused by barking–the stripping of the outer layer for food.

Above left: The droppings of roe deer are a helpful indication of the animals' presence nearby as they are usually found near bedding areas.

Above: A red deer scrape is often found by tree trunks or stumps. Groups of deer paw and stamp the ground as they play around the tree. This behaviour is also particularly common among fallow and roe deer.

Look too for signs of the ways different species feed. Roe are browsers, chiefly feeding on low leaves and shoots. Sika are mainly grazers of fields and open moorland. Other species, such as the fallow and the muntjac, are both grazers and browsers.

A good field guide will be able to tell you where the various deer species are distributed in this country. It is a good idea to do some research into the habits and behaviour of the deer you want to watch before undertaking any practical observation. Apart from the naturally wild red and roe deer and herds of fallow deer in the ancient hunting forests, most deer you see are escapes from parks.

Looking out for deer

Tracks–$\frac{1}{4}$ natural size

muntjac deer

roe deer

sika deer

fallow deer

red deer

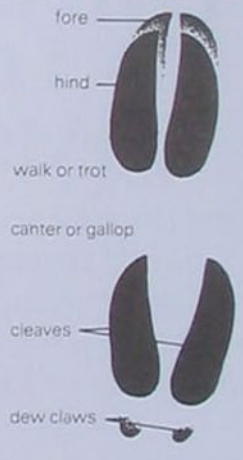
pig

goat

sheep

cattle

Deer tracks at speed



Droppings–$\frac{2}{3}$ natural size

red deer stag
light brown-black, pointed at one end

sika deer
small green-black depending on age, often in heaps

fallow deer
usually black, in lines or piles

muntjac deer
black and shiny, faceted with point at one end, usually single pellets

roe deer
dark brown-black, glossy, may be near bedding area

sheep
dark brown-black, left in large masses

brown hare
brown, round, scattered

goat
brown, shaped like date-stone, in groups

rabbit
brown-black, large numbers in regular latrines

THE DOCK OF LOCH LOMOND

Less than 50 years ago a new native species of dock, previously unknown in Britain, was discovered growing near the banks of Loch Lomond.

As a result of the unprecedented upsurge of interest in natural history pursuits during the Victorian era, Great Britain had, by the turn of the last century, become the most intensively 'botanised' country in the world. Since then, the few additional native species added to the British list have tended to be very small, inconspicuous at flowering or hidden away in some remote, rarely visited locality.

A notable exception to this rule was found in 1935, when a Glasgow botanist, R Mackechnie, collected a tall fruiting species of dock growing near Balmaha, a popular weekend spot on the east side of Loch Lomond. Specimens were sent to the leading authority on docks, who identified the plant as *Rumex aquaticus*, a waterside dock widely distributed throughout central and northern Europe but previously unrecorded in Britain.

Top-heavy stems Popularly known today as the Loch Lomond dock, *R. aquaticus* is a striking plant when fully grown. The tallest specimens can be nearly 2m (6½ft) in height, the pale green flowering heads turning a distinctive golden-brown as the fruits ripen in late summer. Some of the fuller heads make the stems top heavy and they often topple over in the face of strong autumn winds. The large triangular basal leaves (those at the base of the stem) are at their best in early summer for, like other docks, they die back as the fruiting heads mature.

A close relative for which the Loch Lomond dock could be mistaken is the great water dock. However, the spear-shaped leaves and swollen protuberances on the fruits readily distinguish the latter species. The great water dock is most common in the southern half of Britain, whereas the Loch Lomond dock is evidently better adapted to a more northerly environment – in Continental Europe it extends well north of the Arctic Circle.

Distribution past and present Remains of Loch Lomond dock found preserved in peat samples collected in Cornwall and Wales seem to indicate that the species once enjoyed a widespread distribution in Britain. No

Above: The Loch Lomond dock – seen here in fruit – is one of Britain's largest native herbaceous plants, some individuals growing to be 2m (6½ft) tall. As its scientific name, *aquaticus*, implies, this dock grows only where its roots can find a permanent supply of water. On Loch Lomondside the two major habitats are the banks of the River Endrick and its feeder streams, and swampy clearings in wet woods. Occasionally, Loch Lomond dock invades poorly drained meadows, and one lochside colony is growing on a gravelly beach partially covered with silt and sand. Without exception, all the sites are subject to periodic floodings during the winter months.

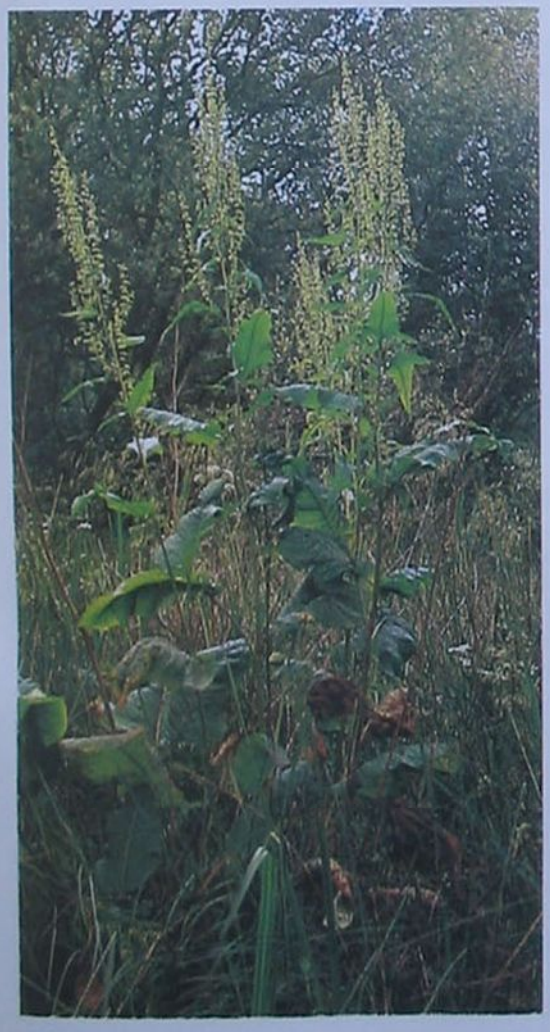
Right: Loch Lomond dock in flower. Although most easily seen alongside water courses, the largest stands of this plant occur in damp woodland clearings. One such wood has an extensive colony of several hundred plants.

single explanation has been offered why the plant disappeared from its former haunts, but climatic change, a loss of suitable wetland habitats and even hybridisation with a more dominant species have all probably played their parts.

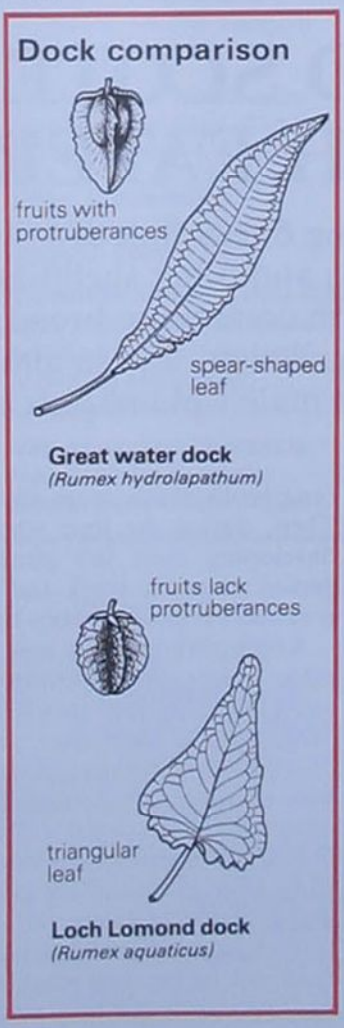
For a while it was thought that the Loch Lomond dock was totally confined to a number of sites scattered around the lower reaches of the River Endrick in the south-east corner of Loch Lomond. Then a few years ago, two small colonies were discovered some distance away in the grounds of a country house on the west side of the Loch. And, as recently as 1982, another well-established population was found beside the River Endrick, but 18km (10 miles) upstream from the mouth.

Hybridisation The Loch Lomond dock is vulnerable in one respect–the readiness with which it hybridises with the common dock, something that the great dock manages to avoid. In general, the drier the site the greater the chance of contact between the two species and subsequent hybridisation.

Hybrids between the two species are not always easy to recognise. However, a combination of intermediate characters–such as less triangular duller-green leaves and reddish rather than golden-brown fruits which, furthermore, have jagged 'teeth' along their lower edges–serve to separate hybrids from pure specimens.



Above: The fruits of the great water dock bear swollen protuberances called tubercles, a feature that serves to distinguish this species from the closely related Loch Lomond dock.



Another difference between the Loch Lomond dock and its hybrid with the common dock is that the former is a long-lived, freely fruiting plant, whereas the hybrid produces partially sterile pollen and its seeds have a lower fertility rate. The replacement of the Loch Lomond dock by the hybrid is, therefore, likely to be a slow process, but surveys show that this is taking place at several sites.

A mystery resolved? A question often asked is why such an eye-catching species took so long to be detected on Loch Lomondside, an internationally famous tourist area.

One answer is the private nature of the country estates where most of the colonies occur. But this is probably only half the story. During the 18th century, the Endrick's flood plain was drained, and there seems to be every likelihood that this caused the population of the Loch Lomond dock to fall considerably, its numbers gradually recovering after the drainage system fell into disrepair. Many of the low-lying arable fields reverted to marshy grazings and damp woods, giving the dock ample opportunity slowly to recolonize some of its lost ground. It is significant that the marshes near Balmaha, where this conspicuous plant was first discovered, had been visited by botanists more than once.

The future The *British Red Data Book* divides up Britain into 10km (6-mile) squares. All those species that occur in 15 or fewer squares are listed as rare. The Loch Lomond dock qualifies for inclusion because it is found in just three squares, though most of the colonies are not faced with any immediate threat. Provided all the important wetland habitats are maintained the future of Loch Lomondside's very own dock seems assured.

EIDERS AND SCOTERS: SHELLFISH EATERS

Eiders and scoters are seafaring ducks that dive in shallow coastal waters to wrench mussels and other shellfishes from the rocks of the sea-bed. They have in common a broad, strong bill to crunch the shells of their victims, and in almost all species a proportion of the male's plumage is black.

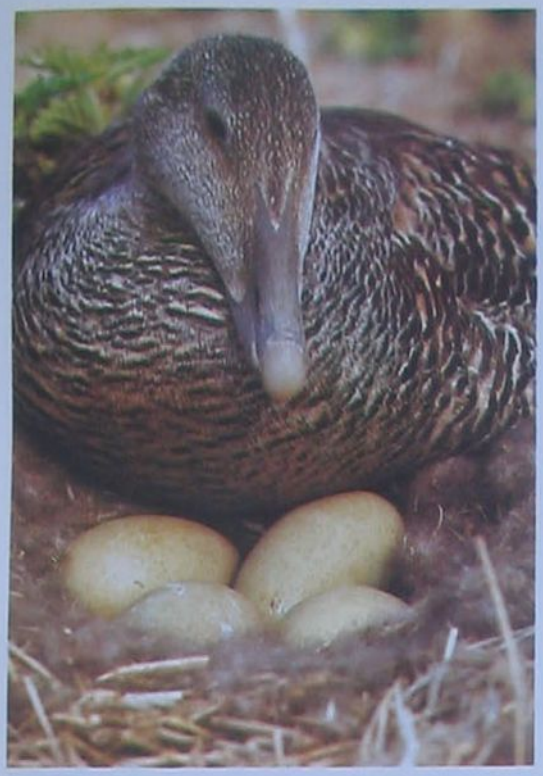
Above: When the young eiders have hatched, they are soon able to walk. The parents immediately lead them to the sea, where they learn to swim. Here, three adult females lead seven chicks—doubtless a 'crèche' in which three broods are combined—to the water. Once on the sea, the chicks have survived their time of greatest danger, for they are out of range of foxes and other predators. These chicks may be all that remain of an original total of about 16.

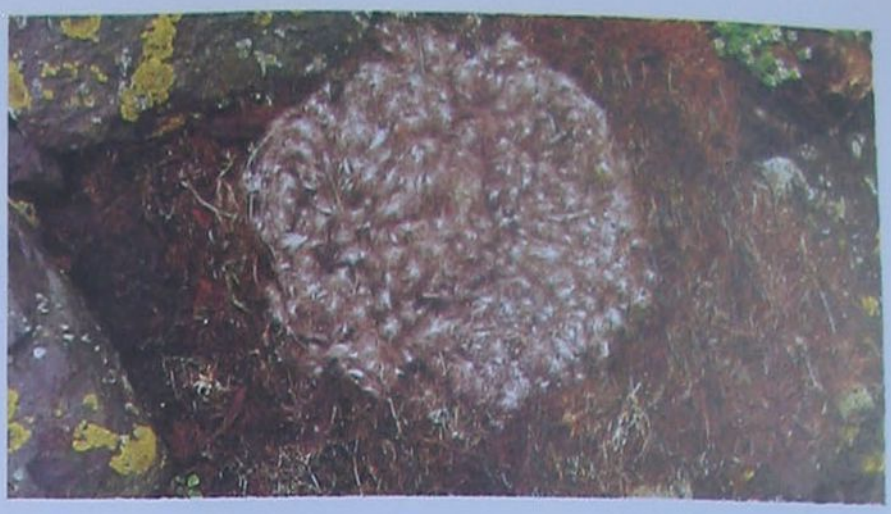
Seen at a distance, the male eider is a handsome black and white bird, with black sides and tail and a black cap on its head, set off by a white chest, neck, face and back. Closer to, one can see more subtle colouring: pastel green on the back of the head, and soft pink on the breast. The bill is dull green and has a lobe on either side running back towards the eye. In complete contrast, the female is brown all over, much mottled and barred in shades of brown to produce perfect camouflage. This is vitally important when she is sitting on the nest, for she must conceal herself from predators.

The male eider also appears in other plumages, for example during the annual moult in late summer: at this time, he loses the majority of his white plumage and for a time looks much more like a dark female. Then, during the time when the males are developing their full plumage, there is a period when the black and white patterning is rather variable between individual males.

Another variation is seen in the immature males. Male eiders do not attain their full adult plumage until they are in their second year, and in their first year they have a distinctive immature plumage; this consists of a white breast, with light and dark brown on all other parts of the bird.

Life on our northern coasts The eider breeds commonly all round the coasts of Scotland, except in the extreme south-west; it penetrates into northern England in Northumberland and, on the west coast, at a few locations in Cumbria. It has been estimated that there





Above: Down falls out of the female eider's plumage, particularly from her breast, and she uses this to good purpose. If she has to leave the nest, she covers the eggs with down (as shown) to conceal them from predators. To keep the eggs warm, she also lines the nest with down. In Iceland and Norway, eiders are 'farmed' or encouraged to breed in special reserves; when they have completed breeding, the down is collected for sale. The down from over 100 nests is needed to fill one sleeping bag.

Above left: A female eider incubates her eggs. Clutches usually contain 4-6 eggs.

are about 20,000 to 25,000 pairs of eider breeding in Britain, making it our second commonest breeding duck after the mallard.

In most of the breeding locations, the pairs nest several metres apart; each nest is placed in a slight hollow, or in the shelter of a boulder or tuft of vegetation. In certain locations, however, especially where there is a degree of protection, for example on a small islet, or where man actively discourages predators such as foxes, large colonies form, hundreds or even thousands strong.

Eiders are not long-distance migrants: after the breeding season, the parents take the young ducks down to the sea and the families leave the breeding grounds. They gather together in flocks in sheltered estuaries and bays. In some locations on the sea, for example the Moray Firth and the mouth of the Firth of Tay, several thousand eiders congregate.

A crusty meal Eiders eat various kinds of shellfish, including mussels, as well as crabs. They crush these in their powerful beaks, discard the hard shells and eat the soft meat inside. Because they live most of their lives in tidal waters, eiders have adapted to feeding in a variety of water depths. Thus they can dive as deep as 15m (45ft) in order to reach mussels growing on the sea-bed. They wrench them off the rocks on which they are attached, and bring them to the surface to eat them.

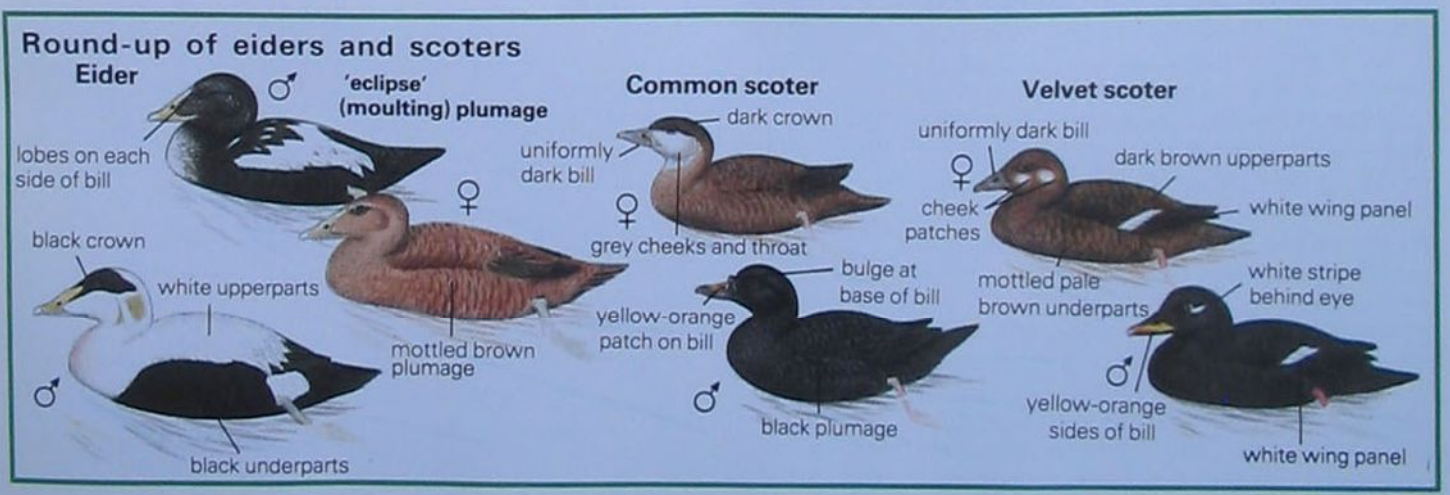
In shallower water, eiders merely upend to reach their food, while in shallower water still they need only dip their heads under the surface to reach the bottom. Another feeding technique is adopted to catch crabs in soft mud. When the mud is covered with a few centimetres of water, the eiders sit over a likely patch and then paddle vigorously with their feet, stirring up the mud and forming a shallow crater. They then probe into the crater with their bills, hoping to feel and then grasp an unwary crab.

Vagrant species Three other species of eider occur in Britain, all as vagrants. All three breed in the Arctic (the king eider most widely) with some colonies in Iceland and many more in Greenland and Spitsbergen. The spectacled eider breeds in north-east Siberia, and Alaska, while the small Steller's eider also breeds in Siberia, with just a handful of pairs in Norway. One or two king eiders and Steller's eiders are seen in most years in the waters around the Hebrides, Orkneys and Shetlands, and some individuals stay there for months or even years.

Eider (*Somateria mollissima*). Diving duck, resident. 58cm (23in).

Common scoter (*Melanitta nigra*). Diving duck; small breeding population; large wintering population. Length 48cm (19in).

Velvet scoter (*Melanitta fusca*). Mainly a winter coastal visitor. 55cm (22in).



Above: The strikingly coloured—and thus very conspicuous—male eider takes no part in the incubation or rearing of the young. This one is therefore merely resting.

Below: A male velvet scoter. In general, the scoter's dives last for as long as 20 or 30 seconds, compared with the eider's longer dives of 30-35 seconds. Both eiders and scoters do, however, sometimes make exceptionally long dives, lasting for over a minute.

Two main scoter species Scoters are shellfish divers like the eider, but can be recognised easily because a greater proportion of their plumage is black. Indeed, the male common scoter is black all over, with a glossy sheen of either purple or green. The only relief to the dark colouring is on his bill, the upper mandible of which has a large yellow-orange patch, outlined in black. Another interesting feature is the black knob at the base of the bill.

The female common scoter is a dull dark brown, with a paler brown face and underparts. Her bill is dark. The pale cheeks and dark crown to her head give a distinctive 'capped' appearance.

The velvet scoter is very similar to the common scoter, and is best distinguished, both male and female, by the white markings on the wings. These show clearly in flight, but when resting on the water they are often concealed. The male velvet scoter has a tiny white patch behind the eye, and the sides of the bill, rather than the top, are orange-yellow. The female has two pale brown patches on her cheeks either side of the eye, and lacks the 'capped' appearance of the female common scoter.

Scoter populations The common scoter breeds in very small numbers in Britain and Ireland; there are a little over a hundred pairs in Ireland, mostly in the north and west, and perhaps 50 pairs in Scotland, again confined to the north and west. In winter, however, many thousands of scoters visit our shores from Scandinavian and Russian breeding grounds, and some also come from Iceland. These flocks are found in various sections of our coastal waters, always where the sea is shallow and usually in a location that is sheltered from the worst weather. Thus flocks of thousands can be seen in the Moray Firth, the Firth of Forth, the Wash, the Thames Estuary and Carmarthen Bay in South Wales. It is thought that between 35,000 and 45,000 winter in Britain.

The velvet scoter does not breed in Britain, but winter visitors from Scandinavia and Russia can be found in eastern Scotland, particularly in the Moray Firth and the Firth of Forth; numbers are usually between 2000 and 3000.

Lakeside breeding grounds The common scoters breeding in the British Isles do so on the banks of freshwater lakes, usually quite large ones. The nests are concealed in clumps of vegetation, often heather, and may be placed on the shore, or on a small island. If there is a suitable island, then several pairs may nest in close proximity. The female carries out all the tasks of incubating the eggs and rearing the young, without any help from the male.

When on the freshwater breeding lakes, scoters live mainly on the larvae of dragonflies and caddisflies, as well as eating freshwater mussels.

Wintering on the sea Both the common and the velvet scoter live on the sea in winter. Here they feed mainly on shellfish—mussels, cockles, clams and whelks. These they obtain by diving, usually in water depths between 2m and 6m (6-20ft). Common scoters and velvet scoters often occur together in flocks in winter, and it seems probable that their diet is similiar, though velvet scoters are more frequently seen close to the shore, and probably find a slightly different range of food here.

The surf scoter This is the only other species of scoter to occur in the British Isles. It occurs as a rare vagrant, chiefly in the north and west of Scotland and Ireland. Its breeding grounds are in North America.

Above: Floating and emergent vegetation on a Norfolk Broads reserve – boats are prohibited here, hence the flourishing plant life.

THE WILDLIFE OF THE NORFOLK BROADS

Created by peat diggings in medieval times, the Norfolk Broads are one of the most outstanding areas for wildlife in Britain. The scenery and vegetation is very diverse, changing from open water with submerged plants, through marginal beds of reeds and lilies, to alder woodland known locally as 'carr'.

Below: A male bearded tit, with a morsel of food, among reeds. This species was extremely scarce between the 1860s and the 1890s, due to egg and specimen collecting, but today as many as 200-300 pairs nest in the Broads.

The Norfolk Broads, an extraordinary series of over 40 freshwater lakes dotted about the flat landscape of East Norfolk and Suffolk, nestle in the river valleys of the Ant, Bure, Thurne, Waveney and Yare. There are over 200km (125 miles) of navigable tidal waterways which discharge into a 6km (3½ mile) long estuary known as Breydon Water, before mingling with the waters of the North Sea at Great Yarmouth. These rivers link some of the Broads and make about a dozen of them easily navigable. The largest is Hickling Broad, with 140 ha (350 acres) of water and reed-bed, but the majority are much smaller. Most are not more than 3-4m (10-13ft) deep.

The open water The lime-laden waters of the rivers, streams and dykes flow, or are pumped, into the Broads. Only a few are

partly spring fed, and only four now retain anything like the abundance of water plants inhabiting them before the complex water chemistry changes that began in the 1950s and accelerated in the late 1960s and early 1970s. Most Broadland water is now bereft of its water plants–such species as water soldier, frogbit and water milfoil–and the reasons for the loss are not yet fully understood.

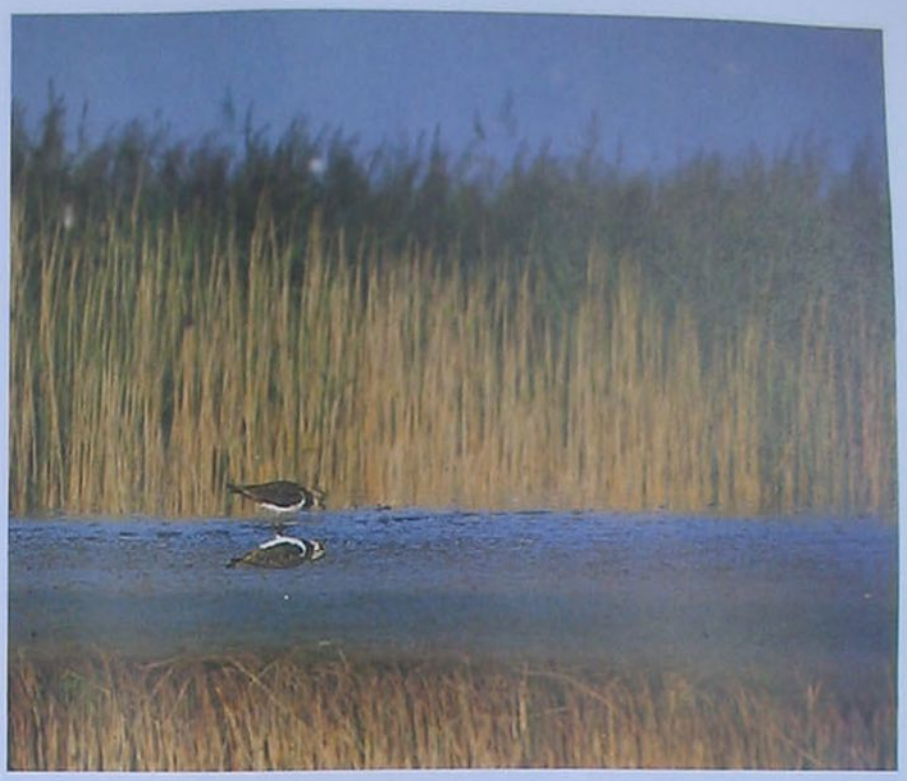
Some 25 species of fishes are recorded from the Broadland. The Broads were known nationally for their pike fishing, but 11kg (25lb) specimens are now rare. Perch were another target species for specialist anglers, and Oulton Broad was renowned for them. Ruffe, roach, tench, bream and eel are the typical fishes found now.

Fishing ospreys are annual visitors to the Broads in spring and autumn on their way to and from Scottish and Scandinavian nesting sites. The handsome great crested grebe was almost erased as a breeding species just over a century ago, due to egg collecting and the use of feathers for hats and muffs, but a few pairs remained on private Broads and the species has subsequently returned in strength. Common terns occur around the Broads, feeding mainly on small fish fry. They first nested inland at Ranworth in 1949, when eggs were laid on derelict wherries. These boats–special shallow draft sail craft which carried commercial commodities between the towns and villages before the days of effective road and rail transport–were sunk to prevent erosion between Ranworth Broad and Malthouse Broad. Over the past 20 years specially constructed platforms and rafts have been used by the terns at Ranworth, Ormesby, Hickling, Cromes, Martham and Hoverton Great Broads, with upwards of 100 pairs now nesting anually on them.

Coot, moorhen, mute swans, mallard, teal, shoveler, gadwall and garganey breed or occur as visitors, while winter weather can still bring a spectacular increase in wildfowl, with tufted duck, pochard, wigeon, pintail, goldeneye and goosander appearing in varying numbers. On the open waters large groups

Above: A flourishing growth of common reeds in Hickling Broad. There are no floating aquatic plants–a situation typical of the Broads that are open to boating and other recreational activities.

Below: A pair of swallowtail butterflies mating. This species is a feature of the Broadland marshes, to which it is restricted. It flies in May and June. The bright green, black and orange ringed caterpillars feed on milk parsley.



of noisy feral-domestic greylag and Canada geese flock at night, accompanied by thousands of roosting gulls. In due season the birdwatcher can hope to spot flocks of black terns on passage, or perhaps a group of pale spoonbills preening in a shallow reed-fringed bay.

Marsh and fen The most interesting habitat within the Broads is that lying between the water's edge and the point at which the sallow bushes start to invade the otherwise open habitat. The Ant valley probably contains the best assemblage of different plant communities within this habitat type, but most areas can be characterised by their particular dominating semi-natural vegetation. An instance of this is in the Yare valley, with its regular tidal rise and fall; here reed sweet-grass (*Glyceria maxima*) dominates the open fen and invades the dykes and Broads.

The Norfolk reed is characteristic of the Broads and river edges, forming extensive beds where it may be harvested on a one or two year cycle to be bundled up and used to thatch many a Broadland barn, farm or cottage. Reed swamp has died back in recent years, while many flowering plants have been shaded out by bushes since regular cutting and burning ceased. The reed-beds are the habitat of many of the Broads' famous birds–the bittern, bearded tit and marsh harrier, for example. The latter has staged a come-back in the past few years, but the bittern is declining in numbers, from over 50 pairs in the mid 1950s to less than a dozen today. Reed and sedge warblers, too, occupy the reed-bed habitat in summer, along with water rails and reed buntings. Grasshopper warblers find the rougher congested fens to their liking, and the similar-sounding Savi's warbler can now be heard calling from at least two localities among dense reeds.

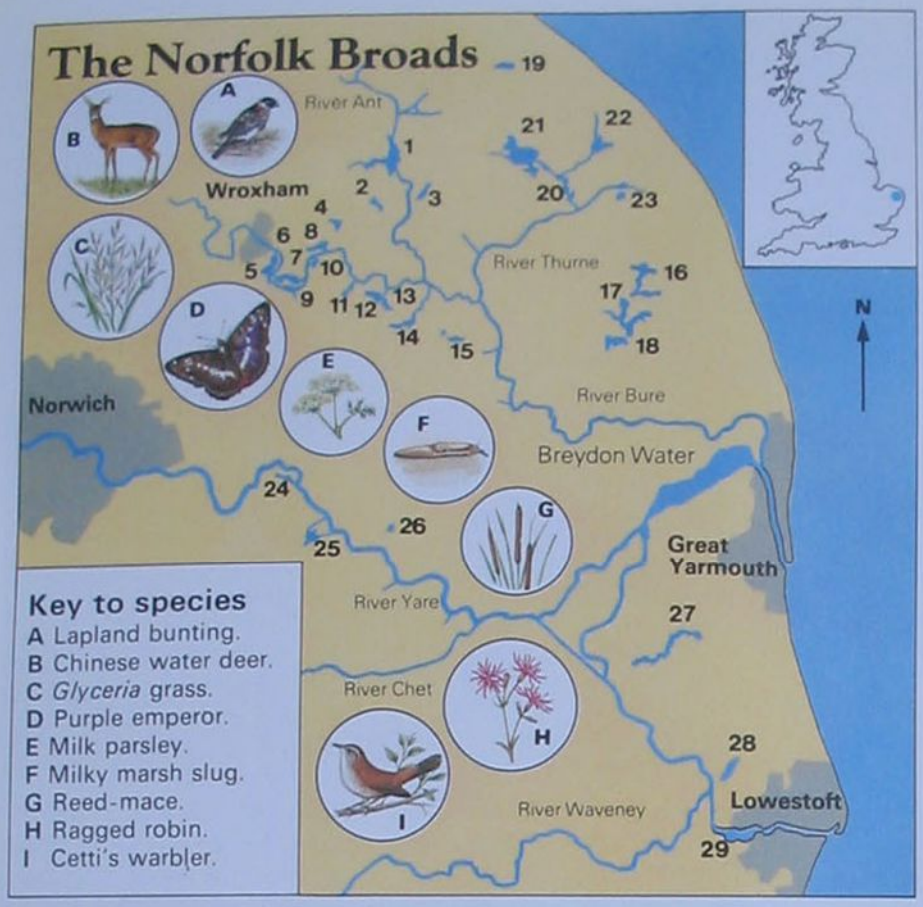
Above: Reeds and a solitary lapwing reflected in the still water of a Norfolk Broads waterway. Lapwings nest on the grazing levels, though in decreasing numbers.

Above left: The rare and inconspicuous fen orchid retains a last and rather precarious station in the heart of the Broads.

Below: A mother coypu and her baby. Brought from the Argentine in the late 1920s, and bred on special farms for their valuable 'nutria' fur, coypus escaped and, finding the Broads much to their liking with an almost inexhaustible supply of aquatic vegetation for food, they multiplied and spread rapidly–becoming pests in the process.

The marsh pea is a locally abundant plant, scrambling among the reeds, while the dampness of the peaty marshes encourages large quantities of the marsh fern. Marsh orchids occur in quantity where the vegetation is not too rank, and among the many other typical plants are ragged robin, yellow flag, greater and lesser reed-mace, saw sedge and tussocks of *Carex*, while the orange balsam, introduced by accident in 1927, is now widespread.

The drier reed-beds and rough grassland probably harbour a greater concentration of harvest mice than any other area in Britain. Strangely, however, it is the introduced mammals rather than the native ones that are often linked with the Broads. The aquatic South American coypu is a well-known example of a successful introduction. Secretive Chinese water deer, too, are now widespread throughout the Broads, with a population probably in excess of 100. The first animals were identified in 1968, but the exact time and place of the original release of these



Above: There are more than 40 freshwater lakes in East Norfolk and Suffolk—this map shows only some of the larger ones.
1 Barton.
2 Alderfen.
3 Cromes.
4 Burntfen.
5 Wroxham.
6 Hudson's Bay.
7 Hoveton Great.
8 Hoveton Little.
9 Salhouse.
10 Decoy.
11 Cockshoot.
12 Ranworth.
13 Malthouse.
14 South Walsham.
15 Upton.
16 Ormesby.
17 Rollesby.
18 Filby.
19 Calthorpe.
20 Heigham Sound.
21 Hickling.
22 Horsey Mere.
23 Martham.
24 Surlingham.
25 Rockland.
26 Buckenham.
27 Fritton Decoy.
28 Flixton Decoy.
29 Oulton.

deer is shrouded in mystery. Otters, too, are elusive; only a few pairs live in the Broads, reflecting the general decline of the species throughout Europe.

Apart from the famous swallowtail butterfly, which occurs in the wild only in the Broads, various other Lepidoptera also inhabit the fens; among these are the wainscot moths *Nonagria sparganii*, *Arenostola brevilinea*, *Senta flammea* and *Leucania obsoleta*. One fenland insect that may have disappeared recently is the large marsh grasshopper, but balancing these losses are such species as *Ishnodemus sabuleti*, a brightly coloured plant bug found chiefly on *Glyceria* and first seen at Wheatfen Broad in 1954—it is now abundant everywhere. Rare water beetles such as *Agabus striolatus* and *Hydroporus scalesianus* still live in the swamps where they were first discovered 150 years ago, and glow-worms still produce their green glow on some marsh banks on warm summer evenings. The larvae of *Lipara lucens*, a small fly, produce the 'cigar' galls on reed stems, while several new species of Diptera are being described from the Broads. Among the invertebrate specialities of the marshes are the milky marsh slug and the slender amber snail.

Right: A Norfolk drainage ditch or dyke—some of the best populations of plants and invertebrates linger in the dyke systems.

Alder carrs A Broadland carr in summer is the nearest habitat in Britain to impenetrable tropical jungle. Alder is the predominant tree species, but sallows also occur, while the slightly drier areas can support birch, ash, oak, hawthorn and buckthorn, with honeysuckle and hops scrambling upwards to the light. All are shallow rooted and gales frequently topple trees, producing a bottomless hole of black oozy mud, while the upturned roots make a nesting place for wrens and kingfishers. The understorey is a thicket of wild currant, raspberry, Duke of Argyll's tea plant and brambles, with masses of nettles. Some tussock sedges are found in swamp carr, as are magnificent royal ferns.

Although these carrs are typically flooded under a foot or two of water for several weeks every winter, small mammals such as wood mice, bank voles and common shrews occur in some numbers. When flood conditions prevail these animals retreat to higher ground and river embankments, or to nests constructed in rotting trees. Their deserted holes, along with cracks in ash trees, are the daytime roosts for pipistrelle and noctule bats.

About 50 species of birds breed in the carrs, while a few more occur as migrants or winter visitors. Heronries are important, with 150 pairs of herons nesting in the early 1970s (although numbers have subsequently declined). Woodcock and mallard nest on the carr floor, while a few long-eared owls re-use old heron nests. Smaller nesting birds include treecreepers, chaffinches and blackcaps, and the more recently established Cetti's warbler can now be found in the brambly edges of the carr. Thousands of rooks and jackdaws arrive in a long noisy black column in the late winter afternoons from adjacent farmland feeding grounds to roost in the carrs. A delightful sight at this time of year is the groups of siskins and redpolls pecking among the alder cones for the seeds.

One mature Broadland alder carr has a large population of white admiral butterflies, while purple emperors have also been recorded, and swallowtail butterflies mate high in the air over the trees.

The grazing levels In the river valleys

one can find large areas of fenland, reclaimed by man in past centuries by digging a criss-cross of ditches or dykes to act as sumps. Some follow old tidal creeks, others are straight cut. They are all linked to a riverside drainage pump which lifts the water into the river.

A flock of 300 wintering bean geese is to be found on the reclaimed fenland in the Yare Valley, but groups of whitefronts or pink-footed geese are an uncommon sight, although several flocks of Bewick's swans now graze the levels. Other regular winter visitors are hen harriers and short-eared owls (which feed chiefly on field voles). These wide open spaces also attract flocks of skylarks and mixed seed eaters such as corn, reed and Lapland buntings.

The breeding season is an exciting time on the levels. Redshank pipe away at any potential intruder, as do the oystercatchers which have begun to nest inland. Snipe bleat over the wetter meadows to proclaim their territory, while in one or two damper areas black-tailed godwits and ruffs linger in haunts where a century ago their ancestors nested. Along the dykes stand herons, while another long-legged bird–the crane–is an occasional autumn and winter visitor to the levels.

No description of the bird-life of these places would be complete without mentioning the two predatory species breeding in the area. By day the kestrel hangs from an invisible 'sky hook', and at dusk the ghostly white barn owl quarters each field for its staple diet of field voles. Barn owls have declined in a spectacular fashion as pasture has given way to arable farming–with the consequent disappearance of the voles. Other occasional food items taken by the barn owl include the water shrew and the water vole –both associated with the dykes. Both birds of prey nest amicably together in the same cowshed or derelict mill.

The ecology of the dyke systems has a very real intrinsic value, but it has been ignored by most people until very recently. Much of the glory of plants and invertebrates that typified the real Broadlands lingers in some dyke systems. Over one hundred flowering plants are found around the dyke systems, many of them quite rare. Water soldier, bladderwort, flowering rush and arrowhead compete with Canadian pondweed, hornwort, frogbit and bur-reed for water space. The native duckweeds compete on the water surface with the introduced floating water fern (*Azolla* sp.), which turns the dykes red in the autumn. Perhaps the rarest pondweed to occur is *Potamogeton acutifolius*, while rare invertebrates living in the dykes include the Norfolk dragonfly (*Aeshna isoceles*) and two small ramshorn snails, *Anisus vorticulus* and *Segmentina nitida*.

The invertebrate fauna can be very rich, but the mechanical dredging now practised can totally deplete the fauna and the flora, as can sheer neglect–allowing the dykes to silt up and disappear as the edges become trodden down and compacted by cattle.

Modern drainage has meant that large tracts of the grazing levels are no longer subject to winter flooding; as a consequence, they have been turned over to arable use. While the occasional arable area among acres of grazing will increase the diversity of habitat, the prairie-like fields created by filling in dykes have limited wildlife potential. A migrant flock of lapwings may congregate, or a group of mute swans may come to graze on the winter wheat, but few species can breed. The dykes, themselves under an arable regime, generally become overgrown with reeds and lack invertebrate diversity.

Among other creatures to find the disappearance of the dykes a problem is the common frog, which lacks areas of water in which to deposit its spawn. Some common toads spawn in the deeper dykes, however, while smooth snakes are widespread throughout the region.

Right: a waxwing perched on a look-out branch. In certain winters small flocks of these colourful birds appear in Norfolk, driven further south than usual by exceptionally hard weather in Scandinavia. Like the larger groups of migrant song thrushes, fieldfares and redwings so frequently seen on the Broads in winter, the waxwings are attracted by the late autumn crop of hedgerow berries.

Below: Reeds being harvested on Hickling Broad. They are cut on a one or two year cycle for use as thatch. Such management is only one of the many conflicting interests in the Broads. One of the more obvious changes in the last 25 years has been a vast increase in the number of boats. It is no surprise to see craft nose to tail on the more congested northern rivers. This disturbance by man and machine has the effect of pushing wildlife away from the rivers–except for the semi-tame coots, ducks and swans that appreciate the holiday-makers' bread supply. The more insidious effects are bank erosion, oil and diesel pollution and muddy water from the spin of propellers–not to mention the spread of litter.

A WEALTH OF EXOTIC TREES

The British Isles are graced with a greater variety of foreign trees than just about any other country in the world. Some are grown here in plantations for their timber but most have been introduced for their decorative flowers, bark or foliage.

A walk through our parks and gardens soon shows that there is a great wealth of different trees in the British Isles, but it would be a mistake to think that they are all native to this country. In fact, we have only 35 indigenous species; the vast majority of our cultivated trees–some 1700 different species in all–were introduced here from other countries throughout the temperate world. The sweet chestnut, for example, comes from southern Europe, the tulip tree forms natural stands in the deep, rich soils or river valleys in western North America, while the maidenhair tree originates in China. Of these 1700 introductions about 600 can be commonly seen in parks and gardens, the remainder being more or less confined to private collections and botanic gardens.

First arrivals It is generally agreed that the Romans first introduced some of our most familiar exotics, such as the mulberry, sweet chestnut and walnut. Evidence that they did introduce some species comes from the discovery of the seeds of the stone pine–a native of Italy–in the refuse heaps of Roman encampments in Britain.

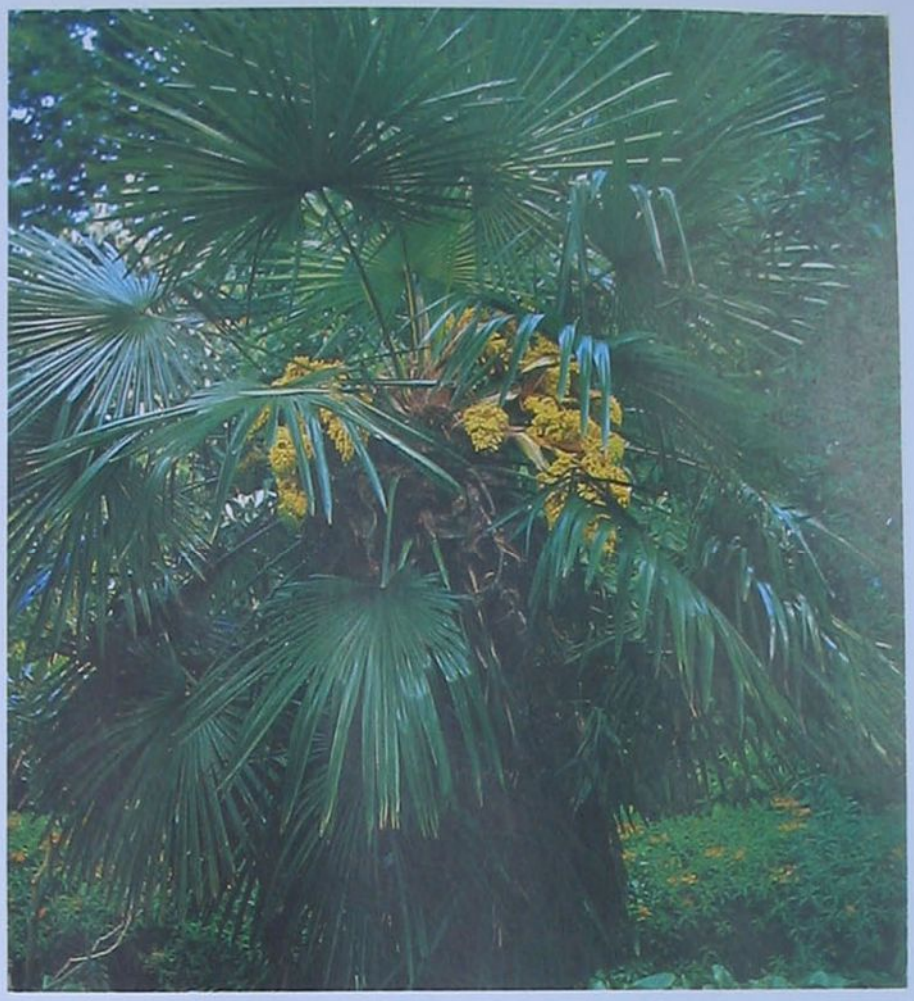
Above: Many of our most ornamental exotics come from the Far East, such as this Japanese maple. Several cultivars of it are grown in Britain. The one shown here, 'Septemlobum', is a small tree planted for its delicate foliage and blaze of autumn colour.

Right: Only a few exotics have managed to become naturalised in this country, the most successful being the sycamore, a species from southern Europe brought over by the Romans.

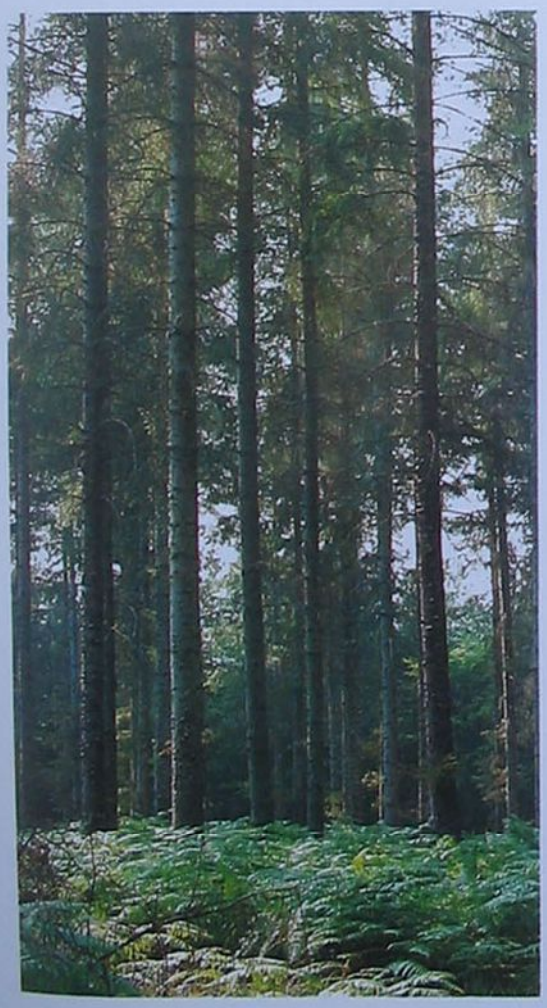
The next major step forward in the cultivation of exotic trees was probably during the 17th century, with the establishment of the Oxford Botanic Garden and the Chelsea Physic Garden. The most noteworthy introduction of this time was the common larch, which was to become, a century later, an important forestry tree. The great pioneer in the cultivation of this tree was the Duke of Atholl, who planted it extensively on his country estate in Perthshire. His son was also interested in forestry and was nicknamed 'the planter', for it is said that during his lifetime he planted 27 million larches.

In 1804 the Horticultural Society (now the Royal Horticultural Society) was founded and, in 1824, it commissioned the great botanist-explorer, David Douglas, to collect plants from western North America, until then a little-known region. Douglas was responsible for such introductions as the Sitka spruce, noble fir and Douglas fir.

The latter part of the 19th century and the early 20th century saw many trees being brought over here from western China, a region with an extremely rich flora. Many plant collectors of this time were employed by nurseries. One such nursery was Veitch and Son, who were fortunate enough to have working for them a most prolific collector called Ernest Wilson. His prettiest introduction is probably the dove tree or handkerchief tree.



Above: Many introduced species grow best along the west coast of Britain, where the Gulf Stream keeps the climate mild from Cornwall up to Scotland. In these areas exotic subtropical trees from the Southern Hemisphere can be grown, and one of the most famous gardens for such trees is at Tresco in the Isles of Scilly. Here, tree ferns from New Zealand and Australian eucalypts thrive alongside acacias from South Africa. Palms from various tropical countries both north and south of the equator also grow here, such as this Chusan palm from southern China.



Left: In commercial forestry, the Sitka spruce is our most widely planted conifer, being well adapted to the cool, humid climate of northern and western Britain—the sites of most of our forestry plantations. In 1965, the area under Sitka spruce totalled about 255,000ha (612,000 acres).

Forestry introductions There are few countries in the world today where exotic trees play a more important role than they do in Britain, and the most important of these roles is in forestry. In 1966 Britain had more than 3 million acres of land under forest, managed as a timber crop. For commercial timber production a tree needs to be fast growing and have a long, straight trunk, both qualities found mainly in softwoods. There is only one such species native to Britain, the Scots pine, and due to the present emphasis on high-volume production it has been necessary to look elsewhere for suitable species.

The most commonly grown forestry tree in Britain is the Sitka spruce. Another much favoured conifer is the closely related Norway spruce, and both the common and the Japanese larch are also widely planted.

Amenity trees The ever-increasing spread of our towns and cities has brought with it a greater awareness of the amenity value of trees. Few of our own native species are used in urban planning, however, because of their low tolerance of air pollution. But there are many exotic trees that can survive these trying conditions, the best example being the London plane. This hybrid between the western and the oriental planes is widely planted as a street tree in southern Britain, where it can grow to a height of 30m (100ft) and live for up to 300 years.

Above Among our most popular street and garden trees are the ornamental cherries, most of which come from the Far East. Many cultivars have been developed, including 'Kanzan', a cultivar of the Japanese cherry.

The false acacia from North America also has much to offer as a town or city tree. In June its racemes of white, pea-like flowers contrast elegantly against a background of bright, pale green, feathery foliage. A close relative of the false acacia, but from southern Europe, is the Judas tree. It prefers the warmer climate of southern England, in mid-May producing bunches of bright rosy-pink flowers. A peculiar feature of this species is that the flowers are borne directly on the trunk as well as on the younger shoots–a phenomenon known as cauliflory.

The horse chestnut must be one of our most familiar and best-loved park trees. It is a native of Albania and Greece, and was introduced into Britain as long ago as 1616. Two other trees that seem to stand the rigours of city life are the Indian bean tree and the tulip tree, both large North American species. For the Indian bean tree, spring starts late, because it is not until June that its leaves begin to appear. It is planted primarily for its bun-shaped panicles of white flowers spotted with yellow and purple and its long dangling pods. During hot summers the tulip tree also produces a marvellous show of flowers. These are, as the name suggests, tulip shaped and stand upright among the curiously lobed leaves.

Ornamental conifers It is among the coniferous cedars that we find the truly majestic species which add such dignity to Britain's stately homes. There are several species, of which the most famous is the cedar of Lebanon, with its layers of flat horizontal branches.

Another conifer often associated with large country estates is the curious-looking monkey puzzle tree. Sometimes known as Chilean or Chile pine, this species became very popular in Britain during the 19th century and was much used in planting schemes.

Garden exotics The private gardener has benefited greatly from the range of species brought into Britain, especially during the past decade with its growth of garden centres. Several types of flowering cherry are now available, as well as such species as magnolias, laburnums and more unusual exotics like Père David's maple with its attractive orange colour in the autumn.

Success or failure Not all the exotic species introduced to Britain succeed here. The reasons why a particular species does or does not survive in Britain are many, but the most important reason is the question of hardiness. The amount of rainfall and the type of soil, for example, both contribute to the success of a tree, but the most decisive factor is whether or not that tree is hardy enough to withstand the lowest winter temperatures.

During the hard winter of 1981-2, the hardiness of our exotic trees was put to the test. Many came through unscathed, while others did not. For example, many eucalypts and bay trees, the former from Australasia and the latter from the Mediterranean area, suffered severely from frost damage, sometimes dying.

The reason why these three species fared particularly badly is that they are all broad-leaved evergreens. In general, such trees are more vulnerable to low winter temperatures than either conifers or deciduous broad-leaved trees. They have no need to shed their leaves in readiness for winter because they come from parts of the world where the winters are mild. By retaining their broad leaves they become very susceptible to our climate.

Below: The London plane owes its success as a town and city tree to the ability of its roots to function in compacted and covered soils; in Britain this hybrid has never been known to blow down.

LICHENS IN OUR CHURCHYARDS

Britain's churches and churchyards provide a wealth of stone surfaces that, for centuries, have been colonized by lichens. Today, however, their peace is being shattered by a combination of pollution and renovation schemes.

More than half the British species of lichen grow on stones yet, throughout lowland Britain, there are almost no natural outcrops of rock, and churchyards provide the only significant areas of old, permanent, stonework for colonization. Indeed, in the agricultural parts of the lowlands, where almost every available inch of land is intensively farmed, churchyards often form oases of wildlife in alien surroundings.

The same is true in towns and cities: in London, for instance, two-thirds of the lichen flora occurs in old churchyards.

Within churchyards there are usually three main stone-based habitats for lichens–the churchyard wall, the memorials and the church walls. The churchyard walls are generally the least interesting of the three, often being rebuilt or repointed at frequent intervals, thus destroying the existing lichen population. The memorials and the church walls are the main lichen habitats.

Memorial lichens Before the middle of the 17th century memorials were normally only erected inside the church to wealthy landowners. Then, in the latter part of the century, it became customary to erect memorials to lesser persons in the churchyard outside. Many fine headstones and tombs were produced during the 18th century and, although the standard of design declined during Victorian times, headstones are still

Above: Lichen-encrusted headstones in a churchyard on the island of Islay in Scotland. Some old rural churchyards can contain more than 80 different species of lichen. Cemeteries and churchyard extensions, however, being much more recent (often 19th or 20th century), are much poorer in lichens.

Right: A typical lichen of limestone memorials, though one reduced in vitality by pollution, is *Caloplaca heppiana*.

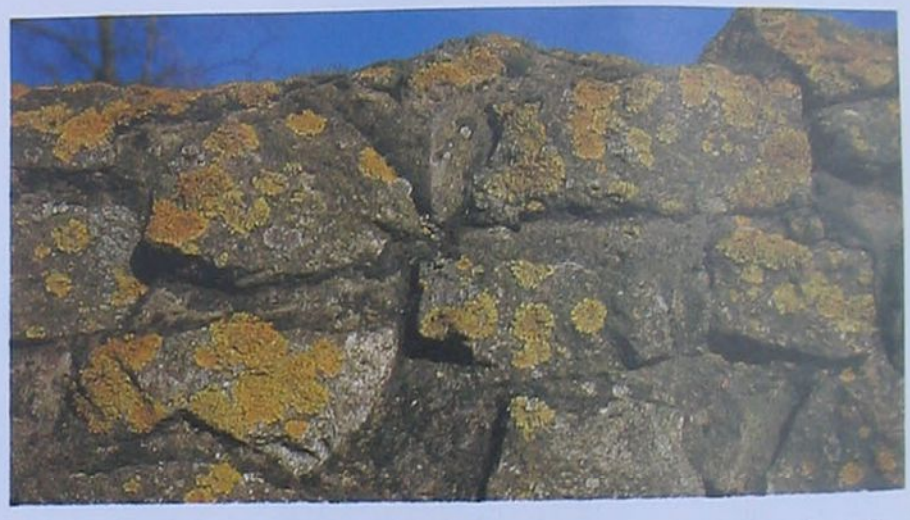
Left: The vivid orange foliose (leafy) lichen, *Xanthoria parietina* on a limestone memorial. From the point of view of lichen conservation, the limestone memorials are far more important than any other type. Marble is also a calcareous stone yet it has a poor lichen flora because of its smooth, polished, crystalline surface.

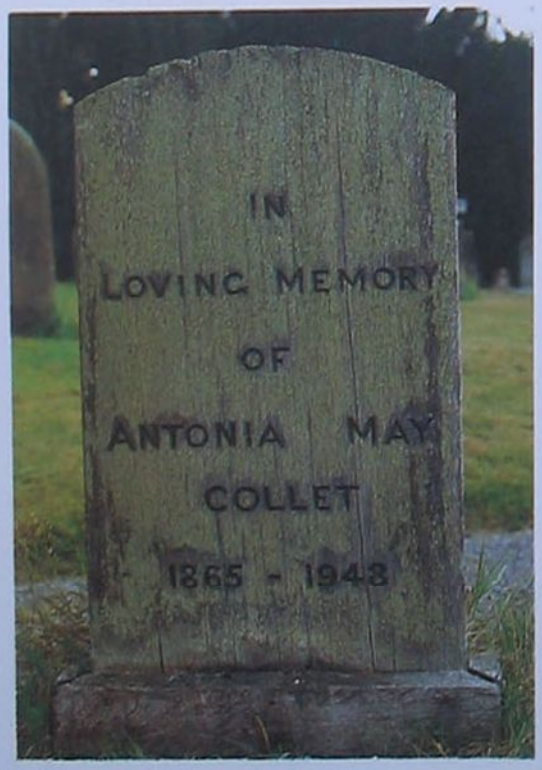
Right: An acid headstone colonized by bright yellowish-green patches of *Psilolechia lucida*. The bluish-grey patches on the ridges, particularly at the bottom of the memorial, are those of another lichen, *Lepraria incana*.

popular today.

The lichen vegetation on headstones falls into two distinct types: calcareous and acid. Calcareous stones–usually limestone–have a varied and colourful lichen flora, with whitish and orange thalli forming attractive mosaics. The stones are often used by birds as perching sites, and nutrients from the resulting droppings benefit many lichens, enabling leafy species such as *Physcia* and *Xanthoria* to flourish on the stones.

Acid headstones are often dominated by greenish, powdery lichens, among which the most common is *Psilolechia lucida*. This species frequently colonizes the grooves of lettering, thus emphasising the inscription.





Above: From the point of view of lichen-hunting, the churchyard wall is usually the least interesting habitat in a churchyard. Yet it may still be worth a look. This wall has been colonized by two species of lichen. The orange lichen is *Xanthoria parietina*, with its darker orange spore-producing bodies. The pale grey lichen is a species of *Physcia*. Both are nitrophilous, ie they thrive in a nitrogen-rich environment such as that provided by bird droppings.

Left: The lichen *Lecanora conizaeoides* is common on wooden grave boards (as shown here) and on acid headstones. Greyish-green in colour and forming a thick crust, its presence indicates that the air is polluted.

The other common green lichen is the pollution lichen, *Lecanora conizaeoides*. This species often dominates sandstones and slate (both of which are acidic) in the churchyards of eastern England. Its presence indicates that the air is polluted with sulphur dioxide.

The effect of pollution Atmospheric pollution has had a more general effect than the encouragement of *Lecanora*. In urban churchyards some of the lichens survive as relicts from earlier times when the church was rural and air pollution less severe.

A good example is the lichen *Caloplaca heppiana*. In London, this species is mostly confined to churchyards with memorials dating from the 18th century and is absent from most cemeteries established during the 19th century.

Another, though less obvious, form of pollution seen in churchyards is that caused by metals such as copper, lead and iron, which are poisonous to plants including lichens. For instance, the water run-off from lead lettering and plaques is conspicuous by the absence of lichens along it.

Lichens on churches The most important habitat for churchyard lichens is often the church itself. About 11,000 parish churches in Britain have walls dating back to medieval times, and a few of these even go back as far as the 7th century. The majority, however, were built in the 12th century and were enlarged later by the addition of aisles and chapels. Thus most parish church walls are now at least 500 years old, a fact that partly accounts for their rich lichen flora.

Unfortunately, the lichens on church walls are often not as old as the original building, usually because the surface of the wall has been replaced or renovated. For example, churches with flint or rubble-stone walls were often plastered originally, a practice that did not cease until the 14th century when the cutting of stone into cubic blocks called ashlar was widely introduced, a technique that enabled smooth surfaces to be built. Most of the plaster remaining on church walls was removed by Victorian restorers, who were fond of exposing surfaces–both inside and outside a church–that were never intended by the original builders to be seen.

The few plaster-coated church walls left by the Victorians are host to a species of lichen found in no other habitat. This is *Lecanactis hemisphaerica*. It occurs on a small number of churches in East Anglia, one in Dorset and another in Kent. In Spain, by contrast, plaster has a remarkable and specialised lichen flora, and it is pleasing to know Britain also has one such gypsophilous species (gypsophilous means plaster-loving).

The stone walls of churches frequently bear lichens that are absent from nearby headstones. Calcareous walls facing north are often covered with grey powdery sheets of *Dirina repanda* forma *stenhammarii*. Other characteristic wall species include *Caloplaca ruderum*, *Lecanora crenulata* and *Opegrapha chevalleri*. The lichen *Ramalina duriaei* is often present on the walls of ruined churches in eastern England.

The species of *Dirina* mentioned above has been able to extend its range greatly by colonizing churches. It is native to shaded cliffs in the west and north of Britain, but is now found on thousands of churches in many parts of the country.

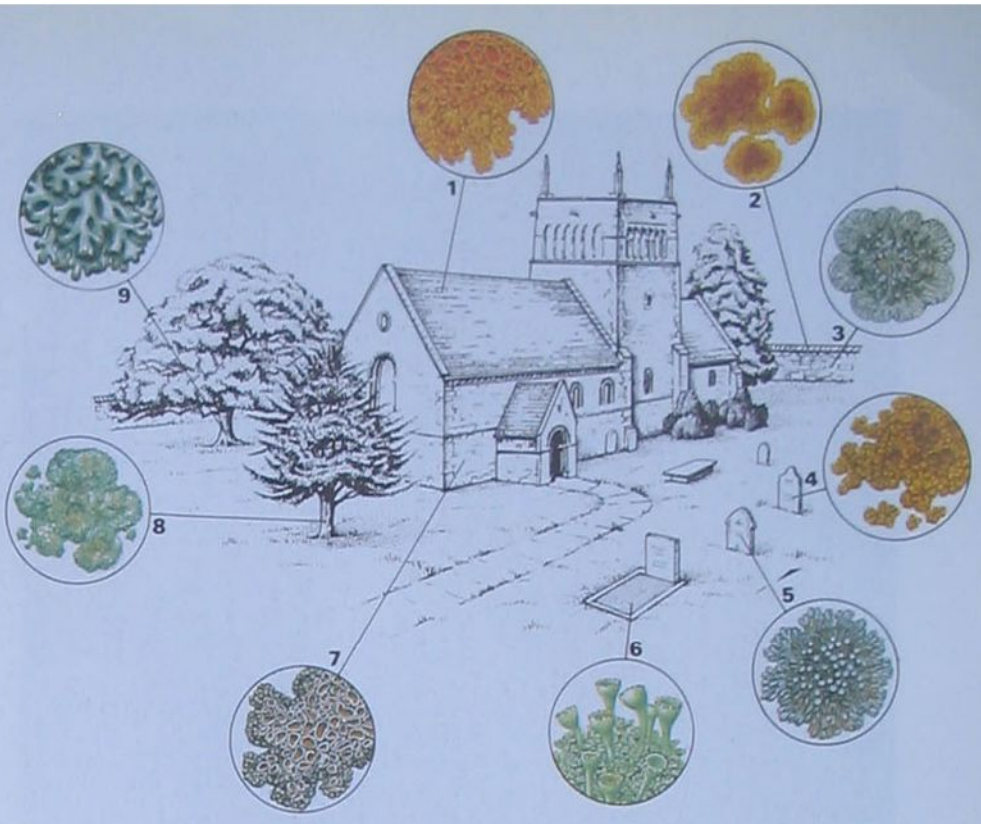
Other sites Many churchyards possess fine trees, which often provide lichens with a suitable habitat for colonizing. The traditional churchyard tree is the yew, many of which are very old. However, yew bark is acid and the trees cast so much shade that they are often completely devoid of lichens.

Lichens are also usually absent from the grassland that so often dominates churchyards. A few have been found on old stained glass in church windows, but this is quite rare.

Future conservation If our lichen flora is to be preserved it is essential that churchyards be protected from those who wish to tidy them up. Memorials should not be cleaned, except where it is essential to read an inscription, in which case the cleaning should be confined to the chisel-work.

More serious is the clearance of headstones from churchyards to allow the resulting lawn to be mown easily and as a general desire to transform the churchyard into a garden. On the other hand, churchyards should not be so neglected that they become overgrown.

The memorials should be retained in the sites where they were originally placed. They have been rightly described as 'stone books recording the history of the parish'. They also record the lichen flora and the dates of colonization. Lichens, too, deserve to rest in peace.



1 *Xanthoria aureola* on church roof (tiles, not leaded).
2 *Caloplaca heppiana* on churchyard wall.
3 *Diploicia canescens* also on churchyard wall.
4 *Candelariella vitellina* on sandstone or slate (both acidic) memorials.
5 *Physcia caesia* on calcareous (usually limestone) memorial.
6 *Cladonia fimbriata* on small stone chippings.
7 *Lecanora dispersa* on church wall.
8 *Lepraria incana* on the bark of a yew tree.
9 *Hypogymnia physodes* on the bark of a deciduous tree.

Above: A variety of lichens on a medieval window ledge of a Lincolnshire church. The orange lichen is *Caloplaca heppiana*. The pale greyish patches are *Haemotomma ochroleucum*, the light-coloured areas being variety *porphyrium* and the greenish-grey *ochroleucum*. These two varieties are remarkable for producing fused lichen bodies, ie both can occur in the same body, each occupying a different area. This may be regarded as a primitive type of hybridisation.

GUELDER ROSE

From its fresh green spring foliage to its crimson autumn colours and bright red berries, the guelder rose remains a colourful shrub for much of the year.

Above: The bright crimson autumn colours of a guelder rose. A hedgerow like this, especially on damp soil, is a likely place for finding this decorative shrub.

Right: The fruits stay on the bush throughout the autumn and on into winter, well after the leaves have fallen.

Below: The outer ring of large showy flowers serves to distinguish the guelder rose from the wayfaring tree and the elder.

Britain has two common native species of *Viburnum*. One is the wayfaring tree and the other is the guelder rose. Both are shrubs, or occasionally small trees, but the wayfaring tree is found mainly on light dry soils in chalky areas whereas the guelder rose prefers moister localities, so the two are rarely seen growing together.

As with most British plants the guelder rose has, over the years, acquired a great many aliases: wild pincushion, muggets, gatterbush and stink-tree (from the scent of the over-ripe berries) to name just a few. In East Anglia the plant was known as king's crown because of its use in making the crown for the May King. Herbalists often used to call it the ople tree, a corruption of the guelder rose's scientific name, *Viburnum opulus*.

Strictly speaking, the name guelder rose belongs to a cultivated form and not to the wild plant. This form, known scientifically as *Viburnum opulus* var. *roseum*, is believed to have arisen about 400 years ago in a province of the Netherlands called Guelderland. The plant was cultivated in the town of Guelders–hence the common name. Nowadays, the cultivated form is popularly known as the snowball tree.

Close relatives The guelder rose and the wayfaring tree belong to the honeysuckle family, Caprifoliaceae, a group that includes twinflower, elder and snowberry, as well as honeysuckle itself. While it is difficult to see any obvious relationship between the shrubby guelder rose and the climbing honeysuckle or the tiny creeping twinflower, its similarity to both the wayfaring tree and the elder are quite apparent. Up to the 17th century the guelder rose was generally known as the rose elder or water elder. All three species form slightly spreading, deciduous shrubs or small trees with pale green foliage and large round clusters of creamy-white flowers. A less cursory examination, however, reveals a number of differences serving to distinguish the three species from each other.

Leaf differences From spring to autumn each plant can be identified quite easily by its

leaves: those of a guelder rose have between three and five irregularly toothed lobes and slightly hairy undersides; the leaves of a wayfaring tree are oval with finely toothed margins and hairier undersides; elder leaves are compound, like those of an ash, with between five and seven separate leaflets.

The guelder rose also has several conspicuous disc-shaped glands at the base of each leaf blade and sharp stipules at the base of each leaf stalk–both features are lacking in the other species.

Flower differences The most obvious differences between the guelder rose on the one hand and the wayfaring tree and elder on the other is in the flowers. In the last two species all the creamy-white flowers in each cluster are fertile and they all look alike. In the guelder rose the flowers in the centre of the cluster look much like those of elder and wayfaring tree, but the ones on the outside are quite different. They are up to 2cm (¾in) across–four times the size of the inner flowers–and are completely sterile, having neither stamens nor ovaries. Their role is to attract pollinating insects to the flower cluster.

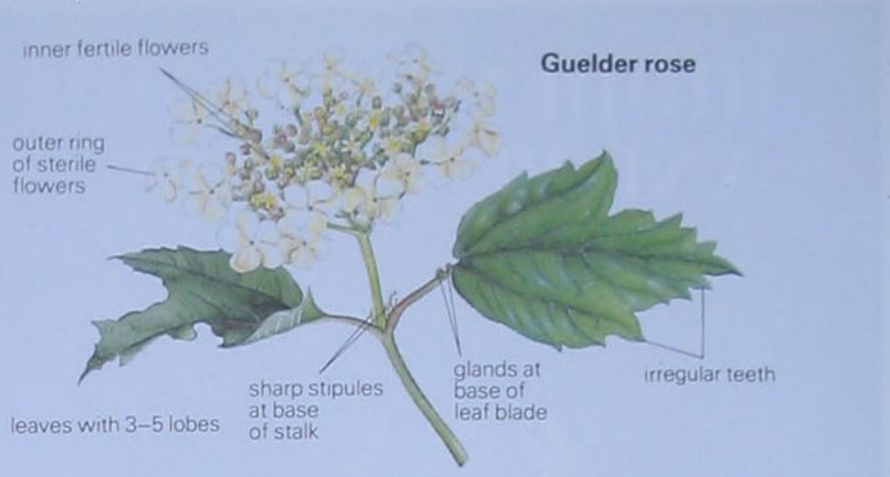
Bright red berries In September the flowers of a guelder rose give way to clusters of berries. The colours of these berries vary considerably–those benefiting from being in full sunlight develop deeper, richer colours than others, and sometimes a single cluster or even a single berry can exhibit a range of colours from golden-yellow through shades of red to deep crimson.

As the fruits ripen they become too heavy for the stalks supporting them and they begin to droop downwards. They tend to stay on the bush for a long time, often well after the leaves have fallen, and add a decorative autumnal touch to otherwise often bare hedgerows. Later in the year, however, as the berries become over-ripe, they darken to become almost black and lose much of their attractiveness.

The berries of the guelder rose, along with its leaves and bark, are poisonous. Yet, despite their attractive appearance, there is little chance of anyone eating enough berries to cause serious harm because they have a very bitter, acrid taste.

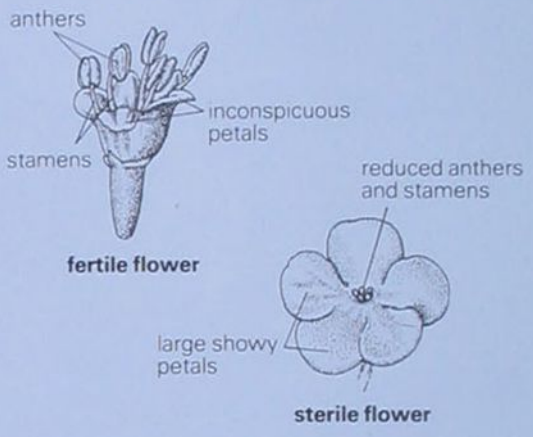
Distribution The guelder rose is widespread throughout Europe and North and West Africa. In Britain and Ireland it is a common species in most parts, though it is absent from the far north of Scotland, which is odd considering that on the Continent it grows as far north as Scandinavia.

In contrast to the wayfaring tree, which is adapted to the dry conditions of chalk downland, the guelder rose thrives on moisture and shows a marked preference for growing on damp soils, often in shady situations. The most common places for finding this shrub are hedgerows and the margins of woodland, but it also grows in more open sites.

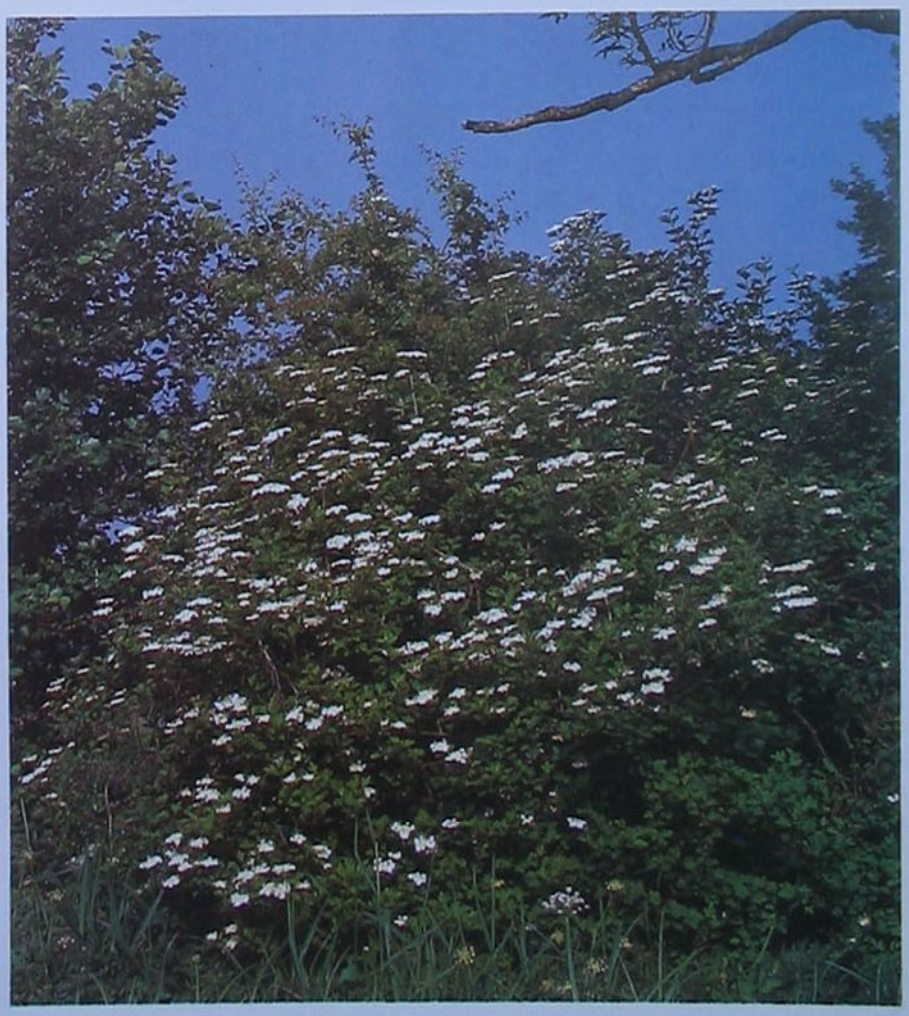

Guelder rose
inner fertile flowers
outer ring of sterile flowers
leaves with 3–5 lobes
sharp stipules at base of stalk
glands at base of leaf blade
irregular teeth

Above: A flowering head of the guelder rose, with details of fertile and sterile flowers (not to scale).

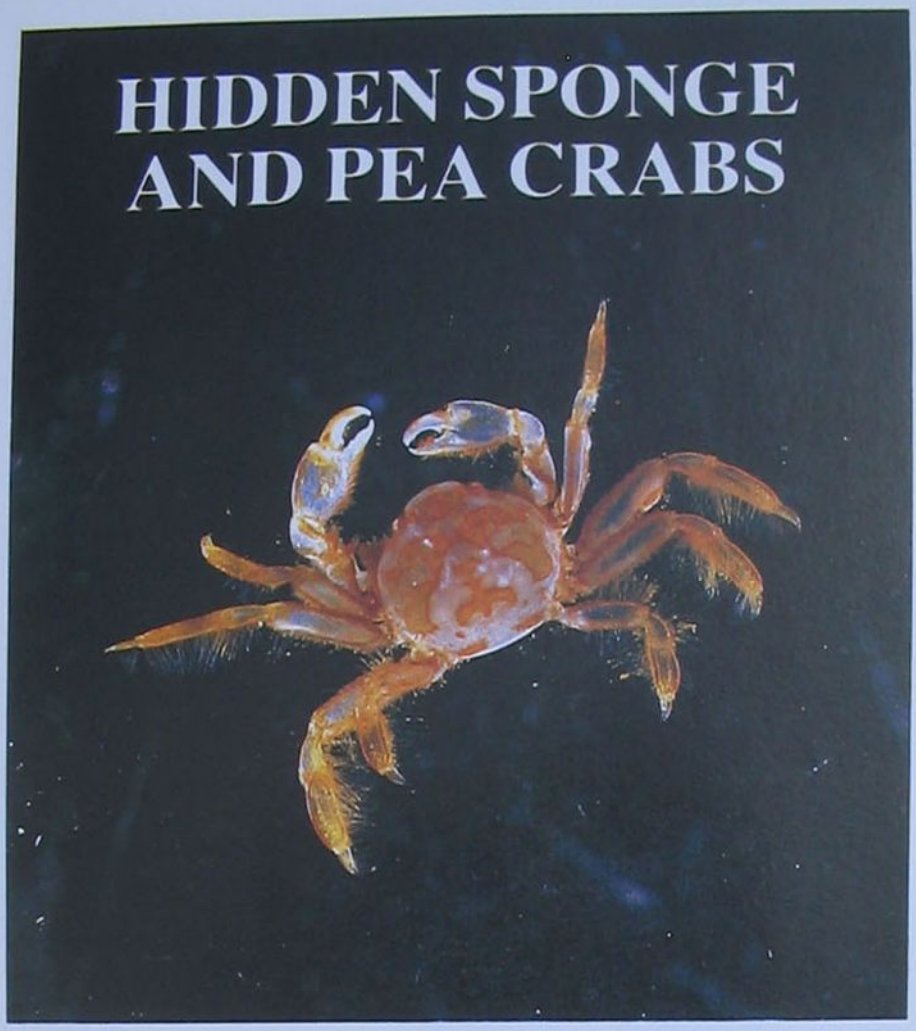
Guelder rose (*Viburnum opulus*). Native deciduous shrub. Widespread in the British Isles, except for northern Scotland.



Below: The guelder rose flowers early in summer–June and July–which is about the same time as the elder and a month after the wayfaring tree.



HIDDEN SPONGE AND PEA CRABS



Sponge and pea crabs have in common an astonishing ability to hide by using other marine animals as protective cover, thus cheating predators.

Above: The male pea crab (*Pinnotheres pisum*) grows to 6mm ($\frac{1}{4}$in) in shell length or roughly half the size of the female. This specimen is in the hard-shelled stage and the long swimming hairs (setae) can be seen on the second and third walking legs. During swimming, the first and fourth pairs of legs are held stationary, while the claws are held out in front of the body.

Below: A female pea crab inside the mussel in which it was found.

It may surprise many to learn that over 50 species of crabs have been reported from the Atlantic waters of the British Isles. This number excludes the porcelain and hermit crabs that, although crab-like, are of a different lineage. True crabs can be recognised by the fact that they possess three main features: all five pairs of legs are conspicuous, the antennae (feelers) are set between the paired eyes, and the ventral (underside) margins of the shell are fused with the mouth frame (in the other two groups the mouth frame is a separate feature).

The true crabs that inhabit our seas have adopted various life styles. Some are efficient swimmers (portunid crabs), others burrow with lightning rapidity into sand or mud (masked and shore crabs) and a few are masters of camouflage (spider crabs). At least three have succeeded in establishing an interesting relationship with other animals, from which they gain protection.

The hat maker The sponge crab (*Dromia personata*) is one of these. This crab is confined to the more southern waters of the British Isles, and its range extends into the Mediterranean Sea. It lives in varying depths down to about 75m (40 fathoms), although it is occasionally found in lower shore rock pools. The shape of the sponge crab is unmistakable: the almost globular shell is covered with a fine brownish pubescence (hair), and the small eyes are almost hidden because they lie in rudimentary eye sockets. The most conspicuous features of the crab itself are the pointed and naked pink-to-white tips of the claws.

Less obvious, but of more significance, are the two posterior pairs of legs: these are dorsally placed (they are attached on the upper surface of the crab), and each one terminates in a pair of small claws. The claws and the angle of attachment to the body provide a clue to the crab's interesting lifestyle, for these two pairs of legs are used to hold pieces of sponge or a sea squirt in place over the top of the shell. The crab thus provides itself with a roof or 'hat' that is carried at all times, whether the crab is walking or at rest.

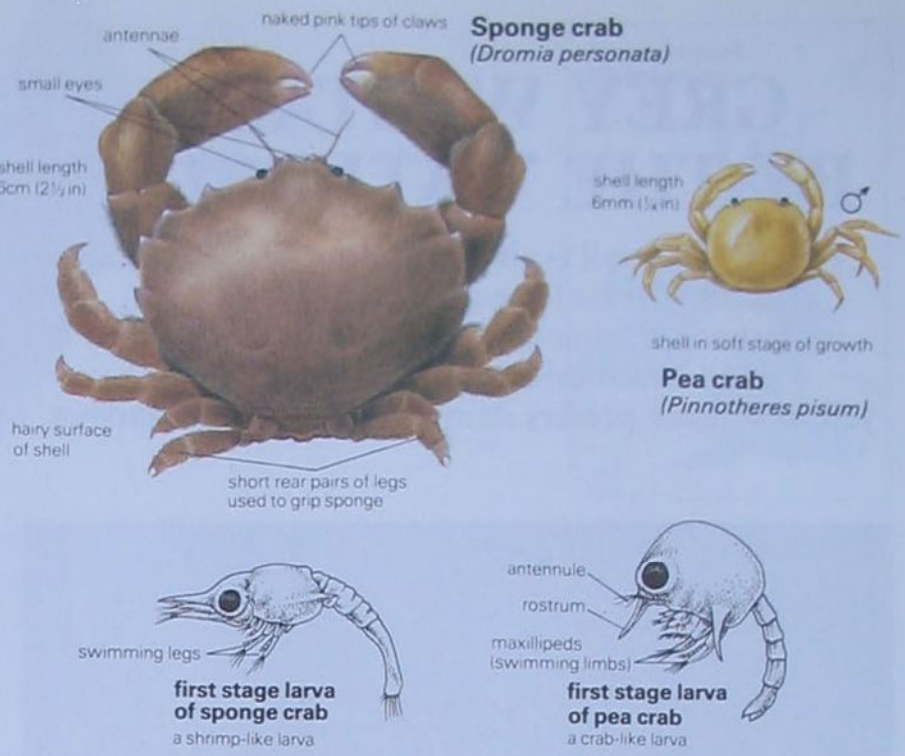
The value of the 'hat' is seen when the crab is under attack from a predator such as an eel or an octopus: if grasped and lifted, the crab quickly releases its 'hat' and scuttles away. It thus escapes to safety, having effectively deceived the predator. The covering also provides efficient camouflage, especially when the crab is among extensive beds of sponges or sea squirts.

Sponge crabs seem to accept any object of sufficient elasticity to allow bending to conform to the contours of their shells. Sea squirts (ascidians) are particularly favoured, as their bodies are pliable and tough. Once acquired, the object can quickly be bent to fit snugly on to the shell surface. The claws of the holding legs usually penetrate the body tissue of the 'hat', which is also damaged in the process of capture and shaping. Because of this the covering eventually dies and disintegrates, and it has to be periodically replaced. This renewal occurs less frequently in the case of small sponge crabs, whose shorter legs probably cause less damage to the host's tissues.

Ancestral link The overall shape of the sponge crab is very similar to that of the other true crabs mentioned above. However, adult sponge crabs have vestigial 'tail fans', which are more characteristic of porcelain crabs, and their larvae are very 'shrimp-like' and superficially resemble the larvae of hermit crabs. These, and certain other less obvious features, suggest that sponge crabs may represent the ancestors of the true crabs found in British coastal waters.

Pea-sized crabs Using other animals for concealment and protection is also a feature of pea crabs. Two species occur in our coastal waters, the pea crab (*Pinnotheres pisum*) and the ancient pea crab (*P. pinnotheres*). These small crabs spend nearly all their lives within the confines of bivalve molluscs (chiefly mussels, fan mussels and cockles) and sea squirts.

The name of the genus to which these crabs belong is sometimes spelt '*Pinnoteres*', which means 'one who watches or guards the *Pinna* (fan mussel)'. Aristotle, the Greek philosopher and naturalist, recognised that there was a mutual relationship between bivalve and crab. Other early naturalists believed that when small fishes swam between the open valves of the mollusc, the crab would give its host a friendly nip that caused the valves to snap shut. This belief was soon disproved when it was discovered that bivalves do not feed upon fishes, and that this relationship is derived from the almost permanent softness of the crab's shell.



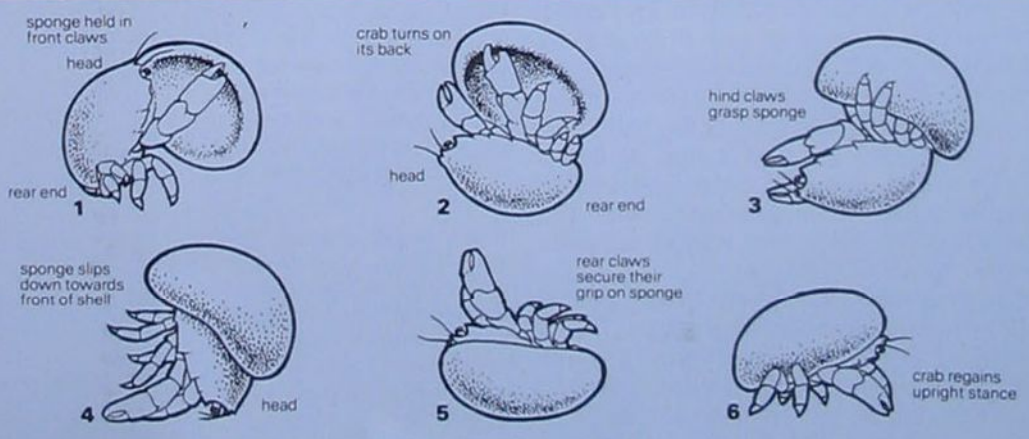
Below: A sponge crab, with its large 'hat' of sponge, its hairy shell and one pink-tipped claw visible.

Protected by a mussel It is now known that the pea crab takes up residence in its host during the first stage of its life after the relatively active larval stages, some of which occur in the plankton. In this first 'crab' stage, the shell is hard and the crab swims by using its second and third pairs of walking legs–these are invested with long hairs (setae) to help the young crab to swim.

Once inside the bivalve, the young crab grows by a series of moults. Throughout these stages it remains soft-shelled, and is without swimming hairs on the legs. The male crab later moults to a hard-shelled stage and re-acquires the swimming hairs. It then leaves its host and searches for a female. Mating probably occurs within the bivalve occupied by the soft-shelled female. The larvae swim freely in the sea.

A sponge hat

The crab cuts the sponge to size and holds it with its front claws (**1**), then turns on its back (**2**) and grasps it with its hind pairs of claws (**3**). The crab then performs a head stand, allowing the sponge to slip along the back of its vertically inclined shell (**4**). The crab locks the sponge firmly in the grip of its hind pairs of claws (**5**) and stands upright (**6**).



GREY WAGTAILS BY THE WATERSIDE

The grey wagtail is similar to the yellow wagtail, except for its blue-grey upperparts. This difference is 'clinched' by the habitat – the grey wagtail lives beside rocky streams, while the yellow wagtail prefers damp meadows and marshes.

The grey wagtail is somewhat confusingly named: although it is true that the upperparts of the bird are a bluish grey, the feature that most often catches the eye is the brilliant patch of lemon yellow on the under-tail coverts and on the belly. In summer this yellow colouring often extends up on to the breast. It is at all times conspicuous, even in birds seen flying overhead. Thus it would seem sensible to call this the 'yellow wagtail'. However, the true yellow wagtail has yellow upperparts as well as underparts; besides its difference in colour, the yellow wagtail is distinguished from the grey by the habitat in which it is seen, for it is a bird of damp meadows and marshes, only occasionally being seen on arable farmland, while the typical habitat of the grey wagtail is beside fast-flowing water.

Changing with the seasons Unlike yellow wagtails, which are migrants visiting us in summer from Africa, most grey wagtails remain in Britain or Ireland throughout the year. Their plumages, however, change with the seasons. In summer, the male grey wagtail has a conspicuous white stripe above and below the eye, and a large black 'bib', while the female's throat is whitish. In winter, the sexes are difficult to separate, both having buffish-white throats and pale buff breasts, with the yellow restricted to the vivid patch below the base of the tail. Young birds are grey-green above and dirty white below, with some dark marks round the throat.

Beside rivers and streams The map of the grey wagtail's breeding distribution shows a uniform coverage of Ireland, much of Scotland, Wales and western England. The only 'blank areas' are in East Anglia, the easternmost Midlands and Lincolnshire. In the western part of its range, the grey wagtail is typically a bird of shallow, fast-flowing rivers and streams, preferring to feed along the waterside or where the water is broken up by pebble banks.

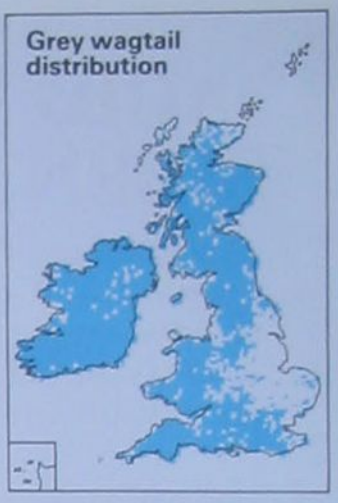
Metallic call Often the first indication of the presence of grey wagtails, if they are not seen flying in an undulating path low over the water, is their frequently uttered call. This is considerably higher-pitched and more metallic than that of the pied wagtail. The grey wagtail's 'tzi-tzi', although formed of two distinct syllables, lacks the harsh emphasis of the pied wagtail's 'chiz-zick' call.

In mild winters, the song starts soon after Christmas. It is often said that the bird sings infrequently and even stops singing early in spring, but this may be because the sound is difficult to hear well against the background noise of fast-flowing, tumbling water. The song, in fact, sounds like a squeaky version of the descending trill of a blue tit's song, or perhaps a treecreeper's song without the terminal flourish. This is so different from the song of other wagtails that if the singing bird cannot be seen, the sound can cause moments of uncertainty even for the experienced ear.

Varied diet The grey wagtail's food consists of small animals – insects for example – that the bird gathers as it dashes nimbly among the pebbles and boulders, or runs across floating water plants. Sometimes a grey wagtail seems to tiptoe along the brink of a weir, risking being swept away by the rushing water. At other times (particularly

Above: The grey wagtail's nest is built by the female (shown here). She performs the bulk of the work of incubation, which takes 13 to 14 days. However, both sexes feed the young. In many lowland areas, two broods are raised, and the season usually starts early. Most pairs produce their first eggs in the second half of April. Natural nest sites include cavities between exposed roots, wall crevices (as shown here), and holes in the banks of streams.

Right: A grey wagtail nest with 5 eggs. Apart from this rather unusual nest site, other man-made sites used by grey wagtails include mills, bridges and weirs. Indeed, a good way to find the birds is to seek out old mills, which are favoured haunts.



Above: Numbers of grey wagtails are considerably lower in eastern England, where the streams are generally more sluggish and offer few suitable habitats.

when columns of midges are 'dancing' in their mating flight) grey wagtails fly out over the water and hover, as flycatchers do, to snap insects from the air. Besides aquatic and terrestrial insects, the birds take a wide variety of small animals, including worms, leeches, flatworms and small freshwater shrimps.

Surviving winter Because their habitat is along the waterside, where a cold winter freeze either kills or covers in ice any animals that the birds need for food, grey wagtails tend to suffer considerable losses in winters with extended and severely cold spells. Upland birds can 'migrate' to lower altitudes in winter without difficulty, but once the lowland streams and lakes freeze, only those birds that can reach a suitable stretch of unfrozen coast can survive. This may help to explain the distribution pattern, with more birds in the west, for the slow-moving streams in the generally colder east freeze quicker, and for longer, than the faster running streams of the west. This makes it rather difficult to estimate the grey wagtail population: numbers are subject to sweeping variations caused by cold-winter mortality every few years. In 1967, following two severe winters, the population was estimated to be below 10,000 pairs, which is probably the lowest level to which it ever falls. Another estimate, of 25,000-30,000 pairs in 1974, reflects healthier circumstances.

Periods of bad weather provoke long-distance winter flights (better called cold weather movements), and ringed birds have been recovered in France, Spain and Portugal. Most flights are shorter, however. Many birds leave their home stretch of water during the period of moult in late summer, and at this time there are records of ringed birds being recovered up to 160km (100 miles) away from their nesting territories. For much of the year, most grey wagtail pairs stay in their territories and defend them: often both sexes defend their territory from a neighbouring pair, with vigorous posturing and mock combat.

Above left: The grey wagtail is distinguished by its combination of blue-grey upperparts and yellow underparts. The extent of the yellow is greater in summer than in winter, and in older birds compared to younger ones.

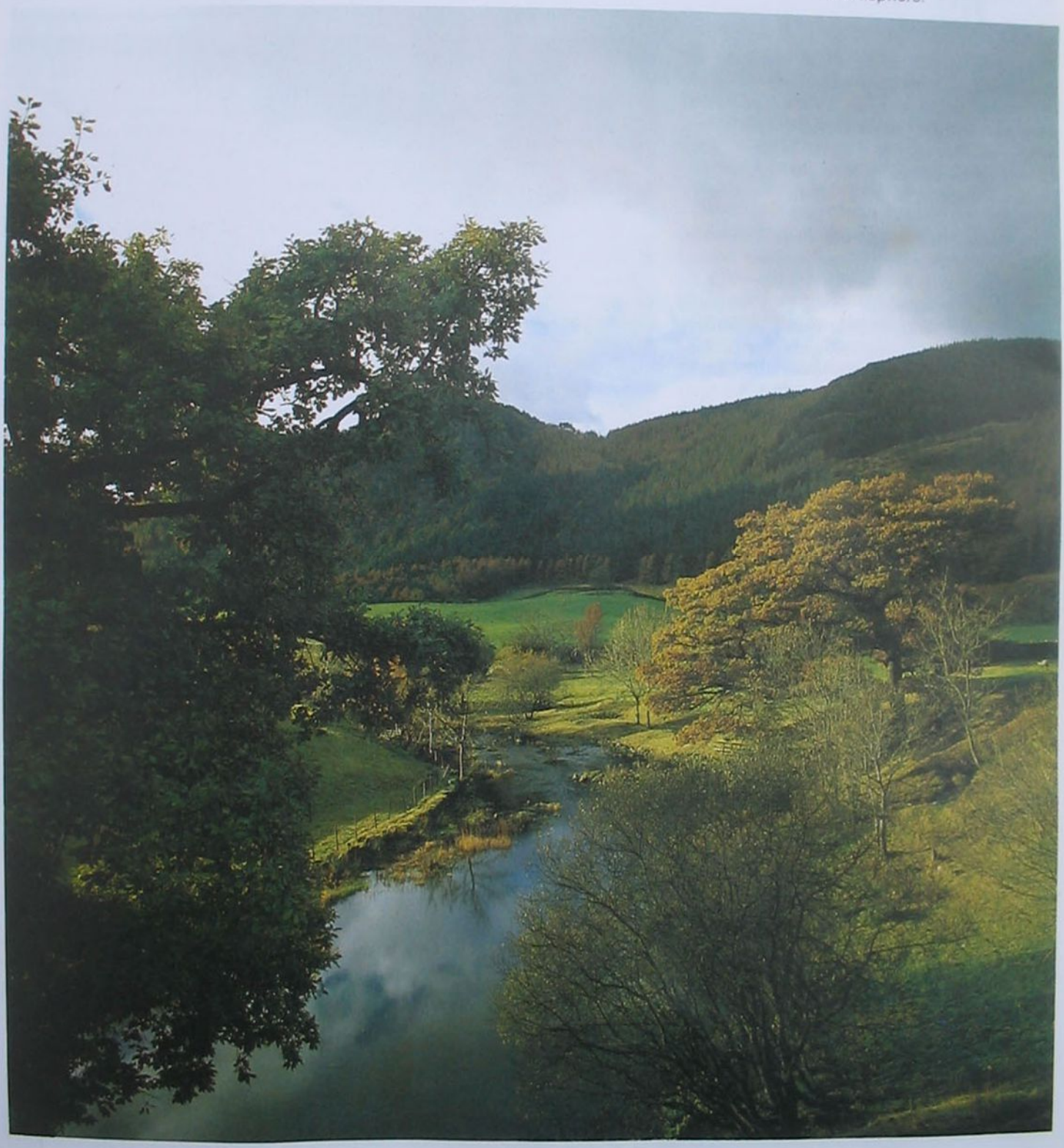
Grey wagtail (*Motacilla cinerea*). Resident bird living beside fast-flowing streams. Moves south in autumn. Length 18cm (7in).

Right: A male grey wagtail lives up to its name—the wagging of the tail neatly recorded by a blurred stripe on the photograph. There has been a considerable amount of debate concerning the reasons for the tail wagging in the wagtail family, with no certain conclusion. However, one theory that is at least plausible is that against the sparkling, ever-changing background of broken water, the continuously moving, white-edged tail helps to break up the silhouette of the bird and give a good camouflage effect.

ACID RAIN: SINISTER, SILENT DESTRUCTION?

Acid rain can fall far from its original source. Its exact development is still unclear, but its occurrence is a reality. In some areas it is associated with changes in plants and animals, including a total loss of fish. The danger lies in the possibly irreversible nature of some of these changes.

Below: The Lake District is just one area of the British Isles to be affected by acid rain. Scientists realised in the 1950s that acid rain might be affecting this country, but it was not until the 1970s that widespread concern was expressed. Evidence of increased acidity has been found elsewhere in Europe and North America, and acid rain is now a common phenomenon in the Northern Hemisphere.



The British climate today is vastly different from that of 250 million years ago; and today's weather is different from yesterday's and is unlikely to be exactly the same as tomorrow's. Some changes, usually the major ones, take place over long periods of time, whereas others occur over much shorter periods. Sunshine, temperature, rainfall, day length and wind together make up the climate; they are physical aspects to which we can respond, as do plants and other animals in their different ways.

In addition to the physical climate, there is the chemical climate. We know that animals breathe in oxygen and give out carbon dioxide, that air contains nitrogen, water vapour and a variety of inert gases; we also know that our atmosphere is likely to contain many substances–pollutants–emitted from factory chimneys, the stacks attached to power stations, and in a more modest way from coal fires or oil-fired central heating in our homes.

What is acid rain? The gases given off when coal and oil–fossil fuels–are burnt are partly responsible for making 'pure' rain acidic. But we must be careful what we say as 'pure' rain, without the inclusion of pollutants, is already acidic. Because carbon dioxide forms a weak acid in solution, pure rain in equilibrium with atmospheric carbon dioxide has a pH (acid value as measured on the pH scale–see below) of 5.6.

Thus the gases given off when fossil fuels are burnt are not the causes of rain being acid, but they intensify the degree of acidity of the rain; pH values of 4.6 are commonplace nowadays, and 3.6 is known. The logarithmic scale which is used to measure pH is complicated, but in simple terms it means that rain with a pH of, say, 4.6 is ten times more acid than rain with a pH of 5.6; and a pH of 3.6 implies a hundred-fold increase.

The acid rain story starts when fossil fuels–coal and oil–are burnt. The sulphur they contain combines with oxygen to form sulphur dioxide. Nitrogen oxides are also formed.

Sulphur dioxide and smoke particles were largely responsible for the smogs that cause so much damage to human health, for instance in London in the 1950s, and in other parts of the world today. To minimise the risks to our health Parliament passed the first Clean Air Act in 1956. Since then, with the introduction of smokeless fuels and a variety of other technological innovations, the release of particulate smoke, as it is known, has been greatly decreased.

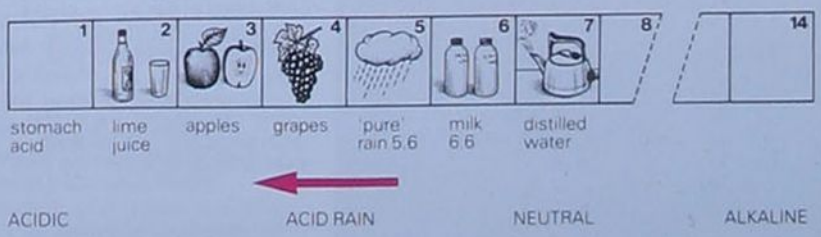
However, the effect on the amounts of sulphur dioxide released into the atmosphere has been very small. Within just two or three days of sulphur dioxide being released most has either been deposited on plants, soil and buildings (dry deposition) or converted in the atmosphere into sulphuric acid and a variety of sulphates which add to the acidity of rain, snow or hail (wet deposition). In its different sulphate forms, pollutant sulphur occurs as very small particules which may be transported or blown for thousands of kilometres.

Above: A power station emits pollutants into the air. The pollution story is complex, concerning sulphur compounds and nitrogen compounds, gases and smoke particles. Near the sources of emissions–power stations, industrial areas and cities–pollution damage is more likely to be attributable to the fumes from mixtures of gases, but acid rain causes damage even here. In remoter rural areas acid rain is probably a greater pollutant, particularly where sulphur dioxide and nitrogen oxides have been blown by the wind and directly deposited on foliage and soil, and then washed by rain into streams and lakes, so increasing the acidity of the water.

Sulphur dioxide is not the only acid-forming gas produced when fuels are burnt. Oxides of nitrogen are also formed and they behave in many respects like sulphur dioxide. A proportion is deposited in the gaseous form, while the remainder is converted to nitric acid. Over northern Britain it has been estimated that 70% and 30% of the acidity in rain attributable to the activities of man is related to sulphuric and nitric acids respectively.

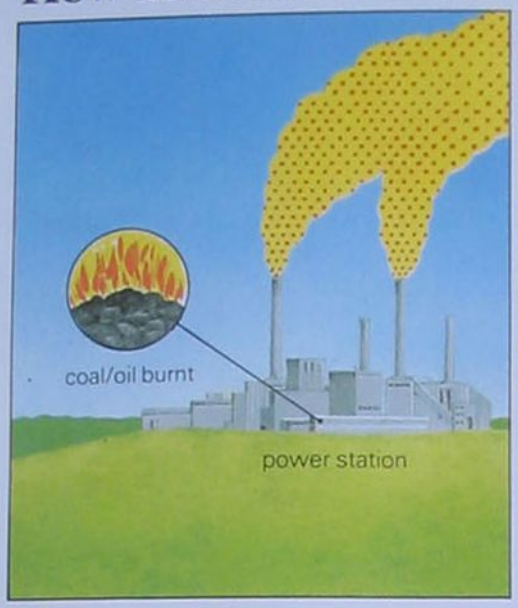
The effects In a country like the British Isles most rain falls on plants, then drops off leaves or flows down stems to the ground. Only a fraction falls directly into streams and lakes, or on barren rock surfaces, mostly in mountainous areas. Although research workers have found from their experiments that artificial acid rain can cause damage when sprayed on plants, we still do not fully understand the effects of acid rain on the

Measuring acidity on the pH scale



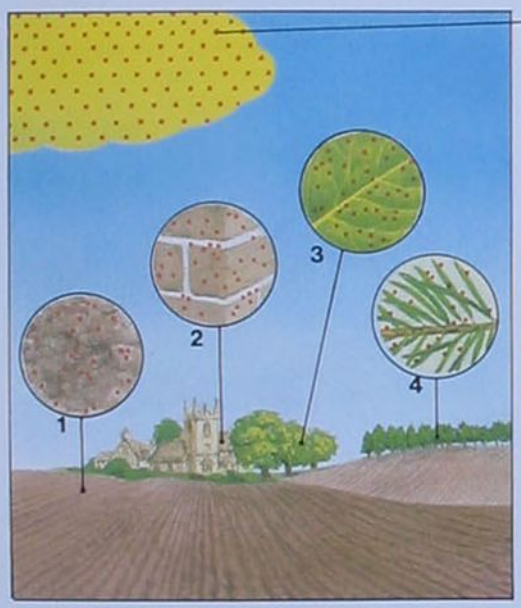
This table shows some everyday items and their approximate degree of acidity. The acidity of solutions is measured on the so-called pH scale. A pH of 7 indicates that the liquid is neutral: the lower the pH, the higher the acidity. Even 'pure' rain, with a pH of 5.6 is acid, but rain with a lower pH is **acid rain**. The greater the acidity of freshwater, the more devastating the effect on the animal and plant life living there. Most fish disappear in water with a pH of 4.5 or below.

How acid rain is formed



When coal and oil–fossil fuels–are burned, rain acidity increases. The fuels' sulphur combines with oxygen (becomes oxidised) to form sulphur dioxide.
Sulphur dioxide is not the only acid-forming gas produced when fossil fuels are burnt: nitrogen oxides are also formed when the atmospheric nitrogen is oxidised at the very high temperatures generated by the combustion of oil and coal. These oxides are also emitted from vehicle exhausts.

Where the pollutants emerge: a major source



quantities of sulphur dioxide and oxides of nitrogen are released into the atmosphere and are directly deposited–

1 on soil and growing plants

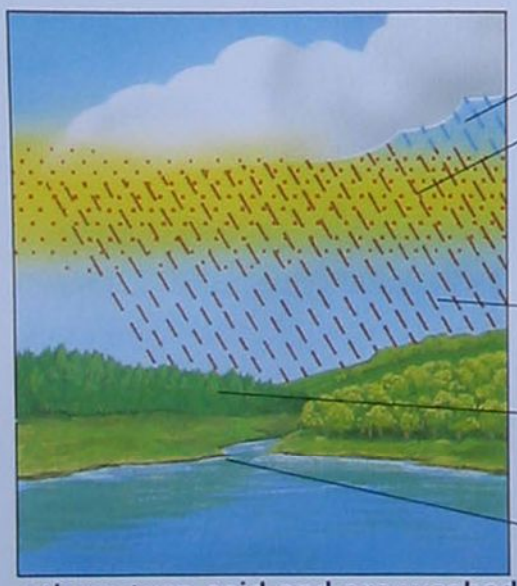
2 on stone which is discoloured and corroded and on other materials

3 on deciduous trees and woodlands

4 on coniferous trees and woodlands

the deposits are later washed from these surfaces by rain, often by **acid rain**

Gaseous pollutants are removed by dry deposition–



pollutants travel far in air masses

'pure' rain

sulphur dioxide and oxides of nitrogen which have not been directly deposited are converted in the atmosphere into sulphuric acid and tiny particles of sulphates, and nitric acid

'pure' rain interacts with the pollutants and falls as **acid rain** (including snow, fog and hail)

substances on the leaves (needles) may combine with acid rain, so increasing the acidity of water that drains away

the acidity of fresh water is now increased, making a less healthy habitat for wildlife

others turn acid and are washed out as 'acid rain'

countryside.

The surfaces of leaves are usually covered with waxy substances which help to minimise water loss and prevent plants from being desiccated. The waxes also protect leaves from diseases, and the nooks and crannies between wax crystals provide habitats for a variety of other bacterium-fungi which may be positively helpful to the plant. For these reasons and others, the effects of acid rain on leaves could be very important, but scientists find it virtually impossible to separate the damage directly attributable to acid rain from that caused by gaseous pollutants, sulphur dioxide and nitrogen oxides. However, there is no doubt that leaves can be badly affected: in polluted areas the needles of Scots pine survive for only one to two years, in contrast to three or more in unpolluted areas. In polluted areas, therefore, leaves die sooner.

Although there are still many uncertainties about what happens to the surfaces of leaves exposed to pollutants, we do know that acid rain flowing over plant surfaces is enriched by substances on the leaves going into solution or suspension. These substances may include pollutants deposited from the atmosphere by dry deposition. In a study in central Scotland it was found that rain dripping (known as throughfall) from the needles of Scots pine had an average pH of 3.7 instead of 4.4–the pH of the rain before it came into contact with the needles. The difference was even greater – 3.3 – when measurements were made of rain flowing down the stems (stemflow) of Scots pine. It is unlikely that the changes would be the same for all tree species: for example, the acidifying effect of birch and ash trees seem to be less.

We also know that the changes are greatly affected by the prevailing concentrations of gaseous pollutants, the changes in the acidity of throughfall and stemflow being larger in polluted than in unpolluted areas. Clearly, it is difficult to make broad generalisations. It is, however, true that vegetation affects the chemical composition of rain as it passes through; and the composition of rain alters the way in which plants bring about these changes. These interactions may prove to be very important.

It has long been known that plants influence soils even when pollutants are not a consideration. This is why farmers periodically apply lime to their land to sustain agricultural production. So it is unlikely that acid rain will damage our intensively managed soils because farmers are continually neutralising them.

But how far does acid rain affect the remaining soils that carry natural vegetation or forests? So far we think the effects on the acidity of soil water are small and slow to appear, although changes great enough to affect the chemical composition of soil solution may occur; these might in turn affect

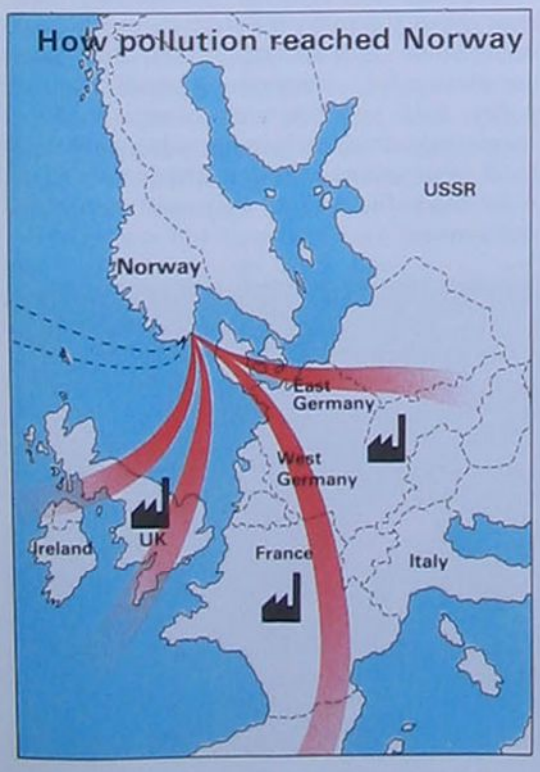
plant growth. As far as we know, this is not happening in the British Isles, although it could be in Germany – we need to be vigilant.

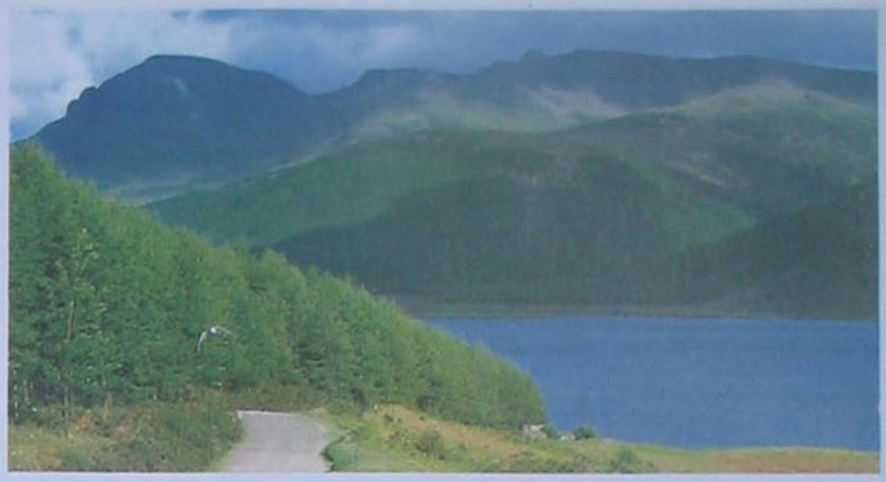
Thus the evidence we have so far on the effects of acid rain on land plants and soils in inconclusive. On the other hand there is consistent, clear evidence concerning streams and lakes. In Norway, Sweden and in the Adirondack mountains of north-east America stocks of fish have completely disappeared. The Norwegians and Swedes suggest that fish have been lost from thousands of their lakes, notably those in southern Scandinavia.

Although conditions in the British Isles are different – we have fewer persistent accumulations of acidic snow – similar losses have been reported recently. For example, lakes in Galloway in Scotland have become appreciably more acid in the last 30 years.

Further, it seems that the risk of acidification is heightened when evergreen coniferous trees are planted. Thus, when examined some years after planting with Sitka spruce, it was found that streams draining this catchment were more acid than those from an unplanted catchment.

In aquatic habitats the increasing acidity has been associated with a change in the balance of minute single-celled plants (microalgae); water insects, caddisflies and chironomid worms replacing mayflies and stoneflies; and, as many people know, a loss of fish, particularly trout and salmon. Much needs to be done to fit together the pieces of the jigsaw, but as far as fish are concerned, the acid conditions prevent hatching, so reducing the number of young. This means that the effect on fish stocks may not be noticed for some time, except in conditions where adult fish are directly affected.





Above: Acid rain pollution of rivers and lochs is worse where already acid soils are afforested, and freshwater wildlife is suffering. It is a particular problem in northern Britain where rain has an average pH of 4.7 in the north and west and 4.3 in the east.

Below left: The map shows 'trajectories' or paths followed by air masses that arrived in southern Norway on four different days in January 1974. In all cases the air had passed over areas of the British Isles and Europe where industry was emitting pollutants into the atmosphere. If a trajectory had followed the broken line, much cleaner air would have arrived in southern Norway. Because pollutants can be transported for such vast distances, the amounts that are deposited in some countries exceed what those countries produce, as is the case in Norway. At some times of the year the excess there is attributed to pollution from industry in the British Isles, while at other times different countries are responsible.

Other parts of Scandinavia and areas in the north-eastern United States and Canada are also badly affected, and numerous lakes and streams are now lifeless. Attempts to reverse the situation by spreading lime have helped temporarily, but the costs involved are vast and in any case they do not attack the cause of the problem.

What can we do about acid rain?

Acid rain is only part of the pollution story: there are also the gaseous pollutants. This article only discusses the actual and potential effects on land plants and freshwater streams and lakes. Together with pollutant gases, acid rain also harms buildings, affects visibility, and so on.

Additionally, we should recognise that some damage may prove to be irreversible. Atmospheric pollutants are not restricted by national boundaries. Of the 4,300,000 metric tonnes of sulphur dioxide emitted by the British Isles, 92,000 and 80,000 metric tonnes find their way to Norway and Sweden respectively. But we receive 53,000 and 43,000 metric tonnes from France and Germany – we all have national and international responsibilities. And finally, in countries such as the British Isles changes in land-use – the increased use of evergreen conifers – may be major contributory factors to the acid rain problem.

The options

1 Do nothing, so dismissing any thought of international responsibility.

2 Reconsider the allocation of land and control changes in its use, so probably minimising the effects of acid rain on streams and lakes.

3 Do **2**, and also minimise the use of energy by decreasing heat losses from buildings by better insulation and other conservation techniques.

4 Do **2** and **3**, and take other measures to decrease emissions. For example, pass legislation to increase the use of desulphurized coal and oil, which might decrease sulphur dioxide emissions by 15%. Also install equipment for fuel gas desulphurization.

5 Do **2**, and switch to sources of energy other than fossil fuels, such as wind power, wave power, nuclear energy, etc.

You pay your money and you take your choice! Would you be willing to consider options **2**–**5** on the strength of the available evidence, or would you opt to do nothing? Today's decisions will affect tomorrow's wildlife.

MINING BEES: SOLITARY DIGGERS

Mining bees, a group of solitary species, are characterised by their relatively short tongues. The females excavate burrows up to 60cm (24in) deep in sand and soil, and even in lawns, sometimes ruining them with their spoil heaps.

Bees are a highly successful group of insects, having been able to tap the nutritious products of flowers by becoming modified not only to take in nectar and transform it into honey but also to carry pollen, usually on their legs.

The simple mining bees usually live in holes in the ground, where they make their cells in a similar way to digger wasps, although they provision them with honey and pollen. Nearly all these bees lead solitary lives, each female digging her own nesting holes, frequently in a semi-colonial fashion, although each hole is quite separate. Unlike bumble bees and hive bees these mining bees do not have a worker caste–all are either males or females.

Primitive species The mining bee *Colletes daviesanus*, one of the less highly evolved bees, is common in July and August in gardens, where it is attracted to garden varieties of yarrow and tansy (its particularly short tongue only enables it to collect pollen and nectar from shallow or flat-topped flowers). Both sexes have shiny black bodies with all the abdominal segments fringed with white hairs; the male's face is covered by silvery hairs.

The female *Colletes daviesanus* makes her burrow in fairly hard ground, sometimes 30cm (12in) deep, and excavates a series of cells, one above the other, in which to store the liquid mixture of pollen and honey. She lines the burrow and makes the cell partitions with a salivary secretion which dries to a waterproof membrane, and then lays an egg in each cell, gluing it to the ceiling. After a few weeks the larvae hatch and feed on the food stores, which are often covered in mould by this time. They pass the winter resting and then pupate in spring.

Bees on the lawn The more advanced mining bees have slightly longer tongues, enabling them to gather pollen and nectar from a wider variety of flowers. The tawny mining bee (family Andrenidae) is one of the more familiar species since it is frequently found in gardens. At 12-13mm ($\frac{1}{2}$in) long it is identified by the bright reddish hairs which clothe its body, and its black legs. This species favours lawns, where the chestnut-coloured females can be seen mining.

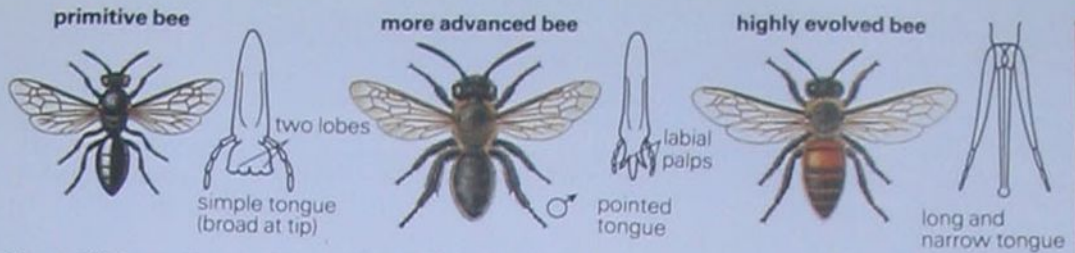
Both this species and another common mining bee, *Andrena jacobi*, are distinguished from honey bees by the dry yellow or orange pollen on their hindlegs; honey bees moisten their pollen with nectar so that it becomes darker. *Andrena* species can also be confused with *Halictus* species–another genus of mining bees–although the former have flatter abdomens.

The *Andrena* species are often common in early spring, making their mines close to each other so that for several metres some dozens or even hundreds can be found. They sink the shafts 15-30cm (6-12in) deep and make the cells either one above another (like *Colletes daviesanus*) or otherwise set at angles to the main shaft.

Although some *Andrena* species line their cells with a silky material, presumably from their salivary glands, this is not as necessary as with *Colletes daviesanus* since their food stores are more solid, resembling a small 'loaf' of pollen held together with honey. *Andrena* species appearing early in the year gather their food from sallow and dandelions as well as fruit trees–for which they are important pollinators.

Above: The hairy-footed flower bee (*Anthophora plumipes*) gathering pollen and nectar. Notice the dry, yellow pollen which has collected on the pollen brushes on its hindlegs.

Below: A species of *Halictus* taking pollen back to its mine. Some members of this genus show a simple social life.



Above: *Hylaeus signatus*, a primitive bee, has a short, simple tongue, enabling it to feed in shallow flowers.

Above: *Andrena fulva* has a short yet pointed tongue so it can feed on a wider variety of flowers.

Above: The honey bee (*Apis mellifera*), probably the most important flower pollinator, has a long slender tongue.

Colletes daviesanus

Andrena fulva ♀

Anthophora sp. ♂

Stylops sp. ♂

Internal parasite
Andrena bees are parasitised by *Stylops*, a minute insect. The adult male (above) lives for 3-4 hours–just enough time to fertilise the female who lives in the female bee's body and disrupts her reproductive system so that she cannot lay eggs.

The tawny mining bee has only one generation a year and is found from April to June. Some *Andrena* species, such as *A. jacobi*, however, have two generations a year, the first in the spring and the second in July and August.

Plagued by parasites The *Andrena* bees have a number of parasites, the more familiar ones being the wandering or homeless bees belonging to the genus *Nomada*. These parasitic bees are comparatively hairless and strikingly banded in yellow and black or brown, giving them a wasp-like appearance. The females lay their eggs in the mining bee cells, and when these hatch into larvae they feed on the mining bee's eggs and food stores.

If you examine *Andrena* bees closely, you may see some tiny yellowish-brown lobes protruding between the segments of the abdomen. These are the females of *Stylops*, an internal parasitic insect that upsets the female bee's reproductive system, causing her to resemble a male and thus preventing her from laying eggs. The male *Stylops*, a minute creature about 2mm long, lives for only three to four hours, during which time he fertilises the female (who remains in the bee's body). She produces several thousand minute larvae, known as triungulins, within her own body.

The triungulins leave their mother's body and probably swarm over flowers, to be picked up by foraging *Andrena* females and taken back to their nests. Here they search for the bee larvae and enter their bodies, staying as internal parasites and not coming out until the adult bee itself emerges from the pupa. Sometimes several *Stylops* larvae may parasitise a single bee host.

Flower bees The mining bees with the longest tongues are the potter flower bee (*Anthophora retusa*) and its relative, the hairy-footed flower bee. Both species are early spring bees, appearing so early in the year that you can sometimes see them gathering pollen and nectar from crocuses.

Although the females initially resemble small black bumble bees (with a rapid flight), they can be distinguished from them by the absence of yellow or red bands on their bodies, by the yellow unmoistened pollen on their tibial hair-brushes.

Flower bee females tunnel into earth and sand banks in April and May, making their cells in the form of clay pots, either from clay found in the burrow, or transported from elsewhere. They line these pots with a salivary secretion which makes them waterproof, and fill them with liquid honey and pollen, on which the eggs float.

Above: Three species of mining bee. Although at a glance they appear similar to honey bees, most species are considerably smaller.

Right: The wandering bee *Nomada ruficornis* is a parasite of the tawny mining bee. Not unlike a wasp in appearance, it can be seen around its host's burrow, waiting for an opportunity to slip in and lay its own eggs in the mining bee's cells. When the parasite's eggs hatch into larvae they feed on the mining bee's eggs and its food stores of pollen and honey.

Below: The tawny mining bee (*Andrena fulva*) is unmistakable with its red hairy thorax and abdomen, and black legs. Common in gardens, it digs its mines in paths and lawns, each hole being surrounded by a small pile of soil particles.

THE NORTH YORK MOORS

Moors, dales and rocky shores: these are the three basic elements of the North York Moors National Park, which abuts the North Sea and lies between industrialised Tees-side and productive arable country.

Opposite page: A panoramic view of the North York Moors. An estimated 50,000 sheep graze some 125,000 acres of moorland, much of it unfenced. Each sheep is 'heafed', which means that in the absence of walls or fences it is inclined to stay on its own tract of moor.

Below: Voles proliferate at the edges of the forestry plantations and attract such predators as the short-eared owl shown here.

Once known as Black-a-more, because of the peat and heather, the name North York (not North Yorkshire) Moors came into use towards the end of the last century. Previously, there were 'black moors' (heather) and 'white moors' (grasses). The Park, designated in 1952, extends to 1432sq km (553sq miles), reaching its highest point on Urra Moor (455m/1489ft), part of the Cleveland Hills. An atmosphere of remoteness is still to be found – that remoteness which caused the raising of a great many moorland crosses to guide travellers. Over 30 of these crosses are named, and Ralph Cross – at the heart of the moors – became the emblem of the Park.

About 40% of the National Park is heather moorland. A profusion of heather, in fact, led to the Park's designation. The hills become, in the east, a range of imposing sea cliffs, with intervening valleys, and the Park has 40km (25 miles) of rocky coastline between Staithes and a point north of Scarborough. The boundary extends to Boulby Cliff, at 203m (666ft) the highest point on the east coast of England. Ravenscar, further south, rises to some 183m (600ft) from the sea. Within the Park are 1610km (1000 miles) of footpaths and bridleways.

The North York Moors National Park is surrounded on three sides by low country. To the north lies the Cleveland Plain and to the west and south are the Vales of York, Mowbray and Pickering, while the Park's western ramparts are the Hambleton and Cleveland Hills.

Geological aspects The basic rocks – Liassic, of the Jurassic Period – are visible on the sides of the dales and by the sea, with some exceptional exposures at Ravenscar. The village of Robin Hoods Bay overlooks extensive scars of Lower Lias. To the north there is a capping of sandstone, and in the south limestone is evident, forming the Hambleton and Tabular Hills. In and around the village of Coxwold, where the limestone has a higher proportion of sand and iron, the stone has a delicate honey tone.

The only volcanic rock evident in the Park – a band of whinstone or basalt – extends for 48km (30 miles) from Great Ayton to Ravenscar; the material was extensively quarried, much of it becoming roadstone. Thin beds of coal – 'fossil fuel' – were used for lime-burning, to improve the fields. Jet, a fossilised wood from coniferous trees, has been picked up around Whitby and, because it took a fine polish, became fashionable as jewellery. Much more significant, however, were the

Above: Robin Hoods Bay at low tide. A wide range of marine creatures can be found in the rock pools here when the waves retreat.

Left: The limestone soils of the southern part of the National Park encourage such species as this wood vetch to flourish.

Below: Fallow deer—a buck and a doe. The forests of the North York Moors National Park support red and roe deer as well as fallow deer.

deposits of alum, worked for nearly three centuries and used by the textile and tanning industries.

Features of special interest in the corallian limestone are the 'windy-pits' of Ryedale, and the caves in Kirkdale, near Helmsley, where archaeologists made interesting discoveries. From the Kirkdale caves were brought the bones of mammoth, rhinoceros and other subtropical fauna that lived before the onset of the last Ice Age.

The influence of man Life would have become tolerable on the Moors for man some 8000 years ago, when tundra conditions followed the retreat of glacial ice. Yet the earliest signs of man of which we are aware date back

only some 5000 years. The Bronze Age is significant because it was during this time that much of the natural forest on the hills was cleared, and barrows – the burial places known on the Moors as 'howes' – were made; they have been found in large numbers.

The natural regeneration of timber was not possible in later times because of extensive sheep-rearing. The sheep ate almost everything that grew. Rievaulx Abbey, in a deep valley near what is now Helmsley, grazed over 14,000 sheep on local moors.

Today, the moors are still grazed by sheep, and heather forms the staple diet of red grouse, which are preserved for sport. The moorland is strip-burned to ensure a continuation of young heather, which is at its peak as a food plant when it is about three years old.

The Moors These are not exceptionally high. The area occupied by moorland is shrinking fast as land is ploughed up for farming or forestry. Over a span of three decades a quarter of what was open moorland has been transformed in this way. The moors are intensively grazed. When the Bridestones Nature Reserve, near Low Dalby, was fenced off against sheep a rapid regeneration of timber began.

Heather moor is still widespread but bogland is limited. (The rainfall on the north-east moorlands is considerably less than that on the high Pennines some 40km/25 miles to the west). The heather, rooted on peat, has been the subject of special study, with attention paid to those areas severely damaged by moorland fires during a drought period a few years ago.

Flowering plants found on the moors include ling, bell heather, cross-leaved heath, bracken, bilberry and tormentil. Adders occur on some of the moors, and birds to be watched for include lapwing, curlew, golden plover and red grouse.

A visitor has easy access to a moorland habitat, for a number of good roads take to the hills. A recommended approach to the Park is through Thirsk and Sutton-under-Whitestonecliffe, followed by a steep climb up Sutton Bank, at the top of which is a large car park and an information centre. After a short walk a visitor can look along the plunging western escarpment of the Hambleton Hills and, if visibility is good, overlook the Plain. Away to the west is an uneven blue line – the Pennines.

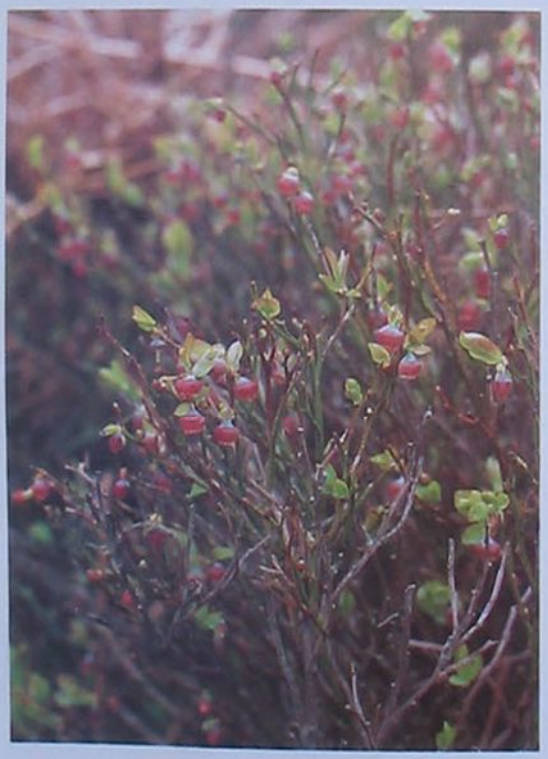
The Hambleton Hills crest at an elevation of some 305m (1000ft). The road eastwards from Sutton Bank includes views of moorland, but there is also newly created farmland and forestland. The road makes a steady descent to Helmsley, in the valley of the Rye. Here the main National Park offices are situated. Stokesley, just outside the Park's north-western boundary, has a road extending through Great Broughton and up Hasty Bank to cross a tract of moorland (the Cleveland Hills) to Chop Gate and Bilsdale.

A visitor who motors northwards from Kirkbymoorside to Gillamoor has the elation of a surprise view, where the Tabular Hills end abruptly, offering a vantage point for Farndale and the moors. Nearby Hutton-le-Hole has a remarkable folk museum, including reconstructed buildings of local style. A road from Hutton-le-Hole crosses the moors to the formidable 'bank' leading down to Rosedale.

Another surprise is afforded by the capacious Hole of Horcum, which is clearly to be seen from the Pickering-Whitby road. Extensive moorland views can be enjoyed until the road descends into the Esk valley

Above: The North York Moors National Park has two outstanding long-distance walks: the Cleveland Way, which follows the coast, and the famous 40-mile long Lyke Wake walk, which starts at Osmotherly and ends at Ravenscar.

Below: The nightjar is one bird to look for at night in the woodlands of the Park. Birds are not profuse on the moorlands but include red grouse, lapwing, golden plover and curlew.



Ling blooms on the moors from early August until late September, but long before its flowers are seen there are patches of purple from the bell heather (above), while cross-leaved heath may be found in the boggier places. A common plant is bilberry (in flower, left). Bracken is spreading in many places and another plentiful species of the uplands is tormentil. It is estimated that about 15% of the Park holds coniferous plantations, and recreation and picnic areas are provided by the Forestry Commission. Low Dalby has a forest centre, and the Forestry Commission has camping and caravanning facilities and also accommodation for visitors in forest cabins.

Information about the Park

The **North York Moors National Park** has its headquarters at the Old Vicarage, Bondgate, Helmsley, York YO6 5BP. Write for a range of leaflets, booklets and posters which are indispensable guides to the area. The **Dalesman Publishing Company**, at Clapham, via Lancaster has published a magazine, *The Dalesman*, for over 40 years and its 300 titles in print include books of interest to those visiting the Park. Write for a book list.

The main visitor centre for the Park is at **Danby Lodge** near Castleton in Eskdale. The **Sutton Bank Information Centre** is open from Easter to October. At Ravenscar, near Scarborough, there is a **National Trust Information Centre**, close to the start of the famous Geological Trail (a waymarked route). There are over 20 *Sites of Special Scientific Interest* in the Park, mostly at low elevations. Forge Valley, near Scarborough, is a **National Nature Reserve**, and in Farndale, where wild daffodils grow by the River Dove, there is a **Local Nature Reserve**.

near Whitby. You can also traverse high moorland by the main Scarborough-Whitby road.

The Dales Here and there on the sides of the dales, or on the lower slopes of the Hambleton and Tabular Hills, is a mixture of indigenous trees–a reminder of the type of woodland that once covered much of the area. To encourage the planting of hardwoods the Park authority provides farmers and landowners with trees to plant on unused ground. Extending from the south towards the heart of the moorland tract is a trio of little dales–Bransdale, Farndale and Rosedale; none of these has a motor road extending directly from its head.

Newtondale, between Pickering and Goathland, is an impressively deep valley, now well wooded with coniferous trees. A restored railway is used by a host of visitors each year, for the trains are hauled by steam locomotives. Eskdale, in the north, a long east/west valley, receives water from the other dales, including Commondale and Fryupdale. To the south of the Park lies verdant Ryedale.

The limestone countryside offers the most interest to botanists. Some notable species in the south of the Park are bird's-eye primrose, globeflower and white bogbean. Clay land in the valleys leading to the sea is botanically interesting, with primroses and drifts of bluebells in spring. Spotted and bee orchids flourish, and there is small scabious, salad burnet and wood vetch, as well as a host of commoner plants. There are eight reserves within the Park, managed by the Yorkshire Naturalists' Trust.

Woods and forestland In the woods and plantations of the southern area are red, roe and fallow deer. The Forestry Commission began planting in the area in 1920 and today the Pickering Forest District (some 30,000 acres) is the largest forest tract of upland heath in England. A conifer forest is a relatively short-lived enterprise; the trees mature quickly and are felled, and then the cycle begins again.

Facilities granted to the public to visit the forests of the Forestry Commission are prominently indicated on the approach roads. Visitors are expected to explore the forests on foot, but deep penetration by car is possible at two forest drives–Hackness to Thornton-le-dale, and in Newtondale.

The coast The 40km (25 miles) of coastline within the National Park is generally of the high cliff type, with expanses of sand in the bays and, near Filey, a 'brig' or extension of rock into the sea. Filey Brig looks like a natural breakwater. The low-tide pools in places like Robin Hoods Bay are of great interest. In contrast to the big bird colonies on the chalk cliffs of Bempton and Flamborough to the south, there is comparatively little bird excitement along the dark cliffs, although gulls nest here and the fulmar is a common sight as it patrols its breeding area.

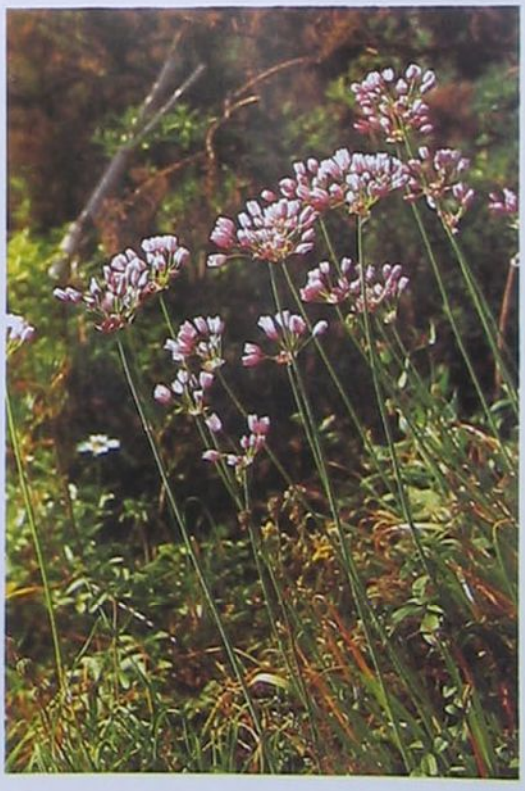
FLOWERS OF THE AVON GORGE

On the west side of the city of Bristol lies the precipitous Avon Gorge–an area which, despite its proximity to a major conurbation, has long been renowned for the rich variety of its wild flowers, including some found nowhere else in Britain.

Throughout most of its journey the River Avon flows sedately through an attractive, but equally sedate, landscape overlying soft limestone. Then, before reaching its destination in the Severn Estuary, the Avon appears to go out of its way to negotiate a difficult route through a much harder form of limestone (called carboniferous limestone) which lies to the west of Bristol. Part of the section includes the spectacular Avon Gorge,

Above: A view south over the Avon Gorge, with the Clifton suspension bridge in the distance and Leigh Woods on the right.

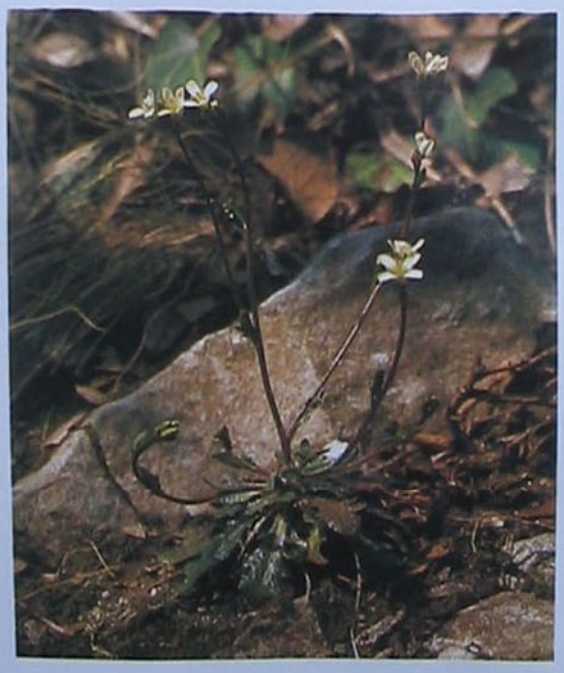
Right: An introduced species, rosy garlic is one of several members of the onion group found in the gorge.



Above: Solomon's seal growing in Leigh Woods on the west side of the gorge. Unlike some plants around the gorge, this species is fairly common in the woodlands of southern Britain. A perennial member of the lily family, it grows to a height of 80cm (2½ft) and flowers in May and June, producing arching stems of white bell-shaped flowers. These are followed later in the year by characteristic bluish-black, fleshy berries.

believed to have been gouged out of this carboniferous limestone by glacial action during the last Ice Age.

The gorge extends for about 2.5km (1½ miles), skirting the city of Bristol, before gradually widening and dropping in height as it approaches the lowlands of the Severn Estuary. Spanned by an elegant suspension bridge built during the last century by Isambard Kingdom Brunel and clothed in woodland and scrub, the gorge has long been a popular spot with tourists. Botanists, however, have been aware of the importance of the site since as far back as the beginning of the 16th century. Today, the Avon Gorge is the focus of continuing research, its reputation as one of the foremost botanical sites in Britain resting on the variety and profusion of wild flowers and the number of rare species found there.



Right: On the opposite side of the gorge to Leigh Woods can be found the rare British rock-cress. In the British Isles, this protected plant is found only in this one area, usually among shaded rocks. Scarcely striking in its appearance, the Bristol rock-cress blossoms between March and May, sending up creamy-white flowers on an almost leafless stem from a basal rosette of rough, dark green leaves.

Leigh Woods The two sides of the gorge display some marked differences in vegetation. The south-western side is the more thickly wooded, consisting of ancient deciduous woodland that extends across country before making a steep descent down to the river towpath. The area is known as Leigh Woods and is a National Nature Reserve owned by the National Trust.

Leigh Woods is a small relict of a much larger woodland that once formed part of Britain's ancient forest cover and the home of a remarkable range of trees. The northern end of the wood is thick with dark green stands of yew and holly. Further south the colour changes to become a paler green as sessile oak, small-leaved lime (an otherwise uncommon native species to limestone areas), ash and whitebeams dominate. Because of its shallow sub-soil, autumn colours come early to Leigh Woods.

The whitebeams are of particular interest because of the presence of two rare species: Wilmott's whitebeam and the Bristol whitebeam, the latter being found nowhere else in the world. Both trees are very similar to the common whitebeam, which is the dominant member of this group in the woods, the main differences being slight variations in the shape of the leaves and their teeth.

Flowers of Leigh Woods The variety of trees in Leigh Woods is matched by the range of herbaceous plants found there–both being clear indicators of the wood's antiquity. These include lily-of-the-valley, whose white flowers are often detected by their fragrance before being seen. Less easily missed is another member of the lily family found in the woods–Solomon's seal, with white bell-shaped flowers that hang in clusters from a gracefully arching stem. Often seen with Solomon's seal is herb Paris, whose symmetrical arrangement of four green leaves, four green sepals and four green petals was once thought to indicate the presence of magical powers.

Along the damper woodland rides, drifts of wild columbine introduce a splash of blue into the world of green, and towards the centre of the woods at the southern end lie the remains of a large Iron Age hill-top fort known as Stokeleigh Camp. Extending over 3ha (7 acres), the damp, rocky remains of the camp provide an ideal habitat for the narrow-leaved bittercress, which grows there in profusion. This species is a tall, bushy member of the cabbage family with narrow, toothed leaflets

and small greenish-yellow flowers.

Another speciality of the wood is the fingered sedge, an inconspicuous plant apart from its fruiting heads, which aptly resemble bony fingers.

St Vincent's Rocks The north-eastern side of the gorge–the city side–is decidedly steeper and more exposed than the Leigh Woods side. This is fortunate for the plants growing there since the adjoining Clifton and Durdham Downs provide Bristol with one of its most popular recreational areas. Despite considerable pressure from visitors and tourists, the precipitous nature of the cliffs on this side of the gorge has helped to safeguard the rare and beautiful species that clothe its sides. The cliffs are known variously as St Vincent's Rocks or Sea Walls.

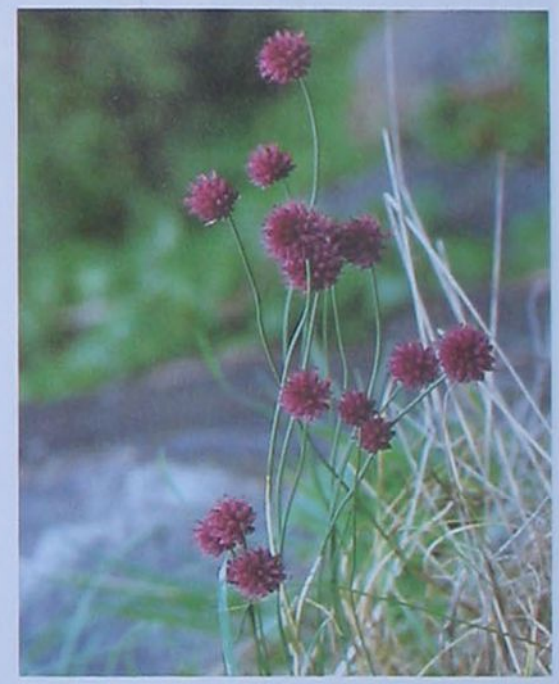
One of several legally protected species found here is spiked speedwell, whose erect spike of handsome blue flowers perfectly complements the deep red blooms of the bloody crane's-bill. But it is not only rarities such as these that provide colour and interest, as the white discs of the ox-eye daisy and the delicate pale yellow of the Welsh poppy testify. Naturalised plants such as wallflower and buddleia also make their contribution.

Several native shrubs typical of limestone scrub are found on the Clifton side, including dogwood, spindle, privet and wayfaring tree.

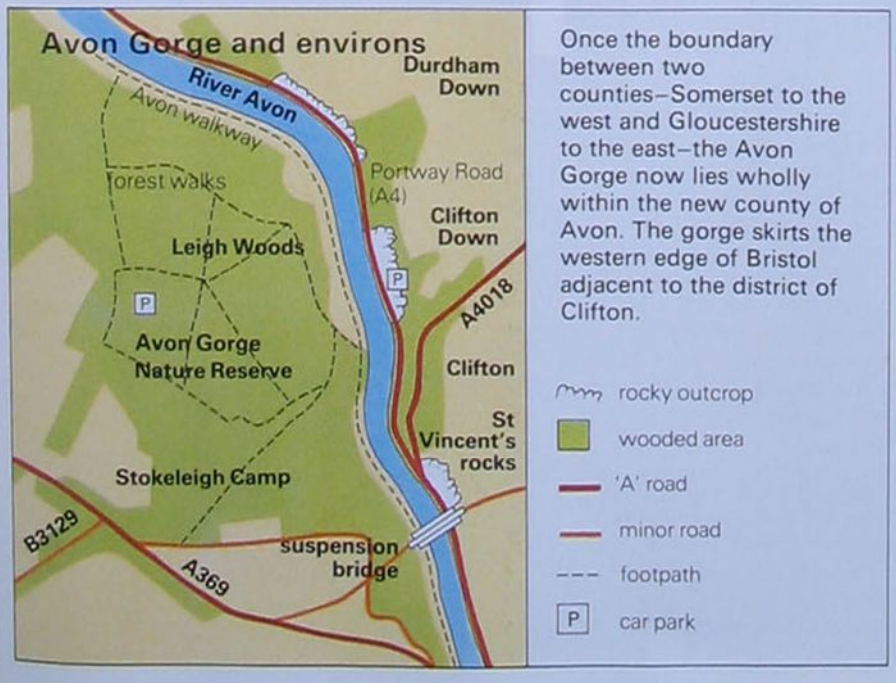
Garlic and leek A peculiarity of the Avon Gorge is the presence of so many species belonging to the onion group. One of these–the round-headed leek–is found nowhere else in the British Isles and is another protected species. Its tall, stiff stems support small round heads of tightly packed mauve flowers. It is readily distinguished from the more common field garlic, whose loose flower heads bear just a few pinkish-brown flowers.

Both these species are native, but the gorge is also home for several other garlics introduced to the area several centuries ago.

Above: A rare plant of calcareous soils in Britain, columbine can be seen along the rides of Leigh Woods. Flowering in May and June, the backs of the bright blue sepals bear spurs containing nectar-producing glands, whose purpose is to attract pollinating insects.



Right: The round-headed leek is, like the Bristol rock-cress, a protected species found in Britain only in the Avon Gorge. Growing to a height of 80cm (2½ft), it flowers in June to August, producing spherical heads on distinctively reddish-purple flowers.



Once the boundary between two counties–Somerset to the west and Gloucestershire to the east–the Avon Gorge now lies wholly within the new county of Avon. The gorge skirts the western edge of Bristol adjacent to the district of Clifton.

These include the invasive keeled garlic, with its distinctive, keel-shaped leaves, and the beautiful rosy garlic, a tall species with pale pink flowers arising on slender stalks from among dark red bulbils.

Seeing the plants That such a concentration of wild flowers should occur so close to the heart of a major city is remarkable and imposes a responsibility upon the plant enthusiast. For instance, it is quite unnecessary to endanger both one's own life and the plants of the gorge by attempting to scale the unstable rock faces since most of the species can be seen (and photographed) at close quarters in the nearby University of Bristol's Botanical Gardens.

To the casual visitor the Avon Gorge offers some beautiful scenery, not unlike that of the Wye Valley. But to those who enjoy seeing beautiful, and sometimes rare, wild flowers in their natural surroundings, the area is one of the finest in the country.

WEBS: WONDERS OF NATURE

Spider webs vary considerably in design so, with a little knowledge, it is easy to distinguish the webs of different spider families.

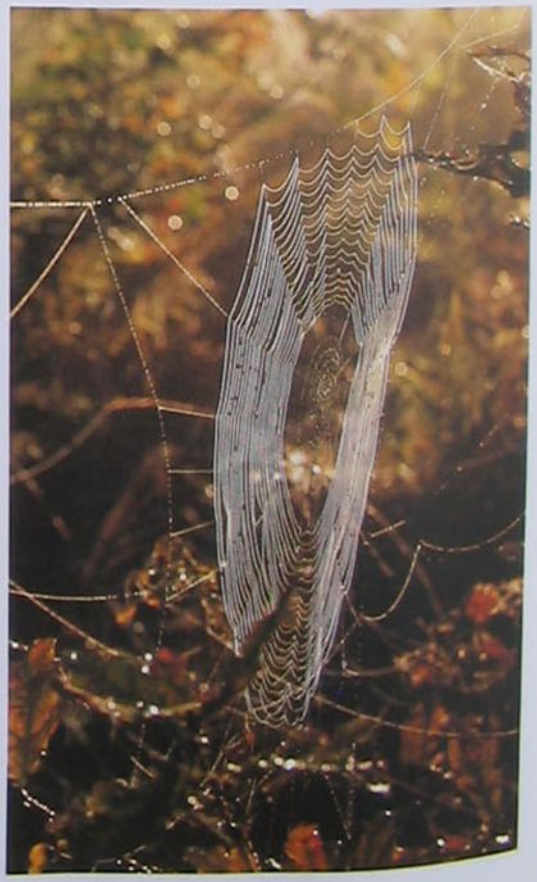
Where would spiders be without their ability to spin silk? Not one species has abandoned silk production and, indeed, the great majority of spiders have many uses for it. These include the building of egg sacs and nursery tents, the emission of gossamer threads for 'ballooning', and the laying of safety lines, but by far the most obvious and significant use is in the construction of webs. The form and strategy of webs vary markedly, reflecting the immense adaptability shown by the spiders themselves in their wide range of habitats from sand dunes to lakes, and from coal mines to mountain tops.

Evolution of webs Since spider webs have no fossil record, their development through evolution can only be inferred. Early primitive spiders were probably nocturnal hunters preying upon insects which were, at that time (400-350 million years ago), wingless. Rudimentary webs, which trapped ground-dwelling prey, were probably initially formed by accumulations of draglines (safety lines) which the spiders trailed behind themselves as they moved around. From this beginning new breeds of spiders evolved which, behaving as trappers, joined the hunters in the competition for insect prey.

It has been speculated that this predation pressure spurred the evolution of insects towards flight as a means of escape. Unfortunately for the insects, spiders responded by evolving the ability to construct the more advanced orb web which, placed above the ground, catches flying insects.

Simple webs A primitive type of web is constructed by the spider *Segestria senoculata*, a member of the family Dysderidae; it has a cylindrical body with a conspicuous adder-like pattern on its abdomen. Widespread and particularly common in dry stone walls, its tubular web comprises a concealed retreat with several straight 'fishing lines' radiating from the hole where the spider lurks. These silk lines communicate vibrations from potential prey, and indicate the direction of the chase. If one

Above: A Christmas tree entangled in hammock webs–a form of sheet web. These, constructed by linyphiid spiders, are found throughout the country among the branches of trees and bushes and in long grass. They are abundant, especially in autumn, although many are so fine that they are difficult to see unless covered in dew.



Right: The orb web is considered to be the most highly evolved of all webs, since it is the most effective trap, despite using only a little silk and taking less time to make.

of the silk threads is gently vibrated by tapping a tuning fork near the web, you may succeed in luring the spider into the open.

Found in similar situations, but also common on trees and around houses, are the meshed webs of *Amaurobius fenestralis* and *Amaurobius similis*. These thick-set spiders of the family Amaurobiidae have a dark mark at the front of the abdomen and a shiny, black head which contrasts with the rest of the cephalothorax (hard outer case).

These meshed webs are much untidier than those of *Segestria senoculata*, but as well as conveying vibrations they also effectively entangle the prey's legs. If you examine a meshed web under a lens, you can see that the network of main threads is surrounded by tangled support threads (calamistrated silk). This woolly and rather bluish web lacks the gluey droplets, which stick to prey, found on many webs and consequently weathers well, lasting a long time before renewal is necessary.

Scaffolding webs Irregular three-dimensional webs are characteristic of the families Pholcidae and Theridiidae whose structures, termed scaffolding webs, are often built in the corners of neglected rooms.

The long-bodied cellar spider *Pholcus phalangoides* is a pale, delicate and rather nervous spider, restricted to the southern half of the country. It hangs upside down in its loose web, and when alarmed shakes so rapidly that both the spider and the web blur. When prey touches any of the threads attached to the walls or ceiling the spider, instead of rushing towards the victim, keeps at a distance and, with the aid of its long legs, draws threads from the spinnerets and flings them over the victim. Only when the prey is securely trussed in silk is the first tentative bite delivered.

The scaffolding web of *Steatoda bipunctata* (family Theridiidae), found in most garden sheds, is studded with gluey droplets. Tight, criss-crossing threads stretch above and below a central tangle, under which hangs the rotund, shiny brown spider. Insects which walk into a thread adhere to the sticky droplets and are lifted into the web as the thread contracts. Struggling only causes further entanglement in the neighbouring threads, and as the spider throws more gummy silk over the unhappy victim it finally delivers a *coup de grâce* by injecting a potent venom into the prey's nearest leg. Beetles, which might break free by sheer strength, are quickly defeated by *Steatoda bipunctata*.

Some theridiid spiders, for instance *Achaearanea riparia*, build a retreat consisting of a long silk tube which hangs downwards in the middle of the web and is heavily camouflaged with plant material.

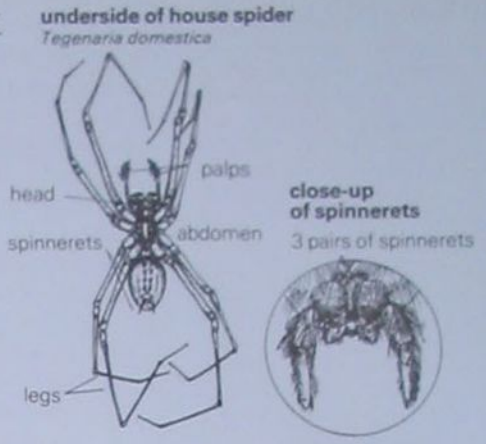
Cobwebs and sheet webs The unwelcome cobwebs, which are the work of house spiders (mostly *Tegenaria* species), are sheet-like, usually with a retreat in some dark corner. The brown hairy spiders dart in and out of the retreat, running on the surface of the web with an upright stance. These cobwebs are most effective in catching crawling invertebrates, but as they lose their efficiency when covered in dust, new webs are built while the old ones just accumulate dust and dirt in the corners of abandoned rooms and houses.

The more attractive sheet webs are built by the silvery members of the family Linyphiidae (money-spiders). These rather delicate webs are either dome-shaped or they resemble hammocks, and include hundreds of prey-entangling trip threads.

A feat of engineering The orb web, a two-dimensional structure (unlike sheet webs, scaffolding webs and cobwebs), is considered to be the most highly evolved and effective

Spiders and silk

A spider secretes silk with the spinnerets at the end of its abdomen, and the silk immediately hardens on contact with air. Since silk is the strongest natural fibre known, spiders have numerous uses for it. Apart from building webs, they use silk for constructing retreats, egg sacs, nurseries for spiderlings, laying safety lines and wrapping up prey or–in the case of some species–even their prospective partners.



Araneus quadratus, a colourful orb web spider found on heaths and moorland, uses its silk to build a formidable egg sac (right).

Below: The hammock web of a linyphiid spider. Unlike some of the other sheet web spiders, the spiders of the family Linyphiidae, hang upside down beneath their webs. When an insect is trapped by the silken threads (seen at the top of the gorse) the spider shakes the web, causing the victim to fall into the sheet section, where it then bites the prey. Other sheet webs may be dome-shaped, such as those made by *Linyphia marginata* and *Linyphia triangularis*.

Ballooning

Most linyphiid spiders, and the spiderlings of some other families, migrate by means of airborne dispersal. They climb on to a high point–the top of a fence post or a plant–and squeeze silk out of their spinnerets; this is blown upwards by air currents and drawn out. The pull of the silk threads by the wind is strong enough to lift the spiders into the air and carry them away–a phenomenon known as 'ballooning'. The distances covered by the spiders can be vast: Darwin records that on the voyage of the *Beagle* large numbers of spiders landed on the ship while in the South Atlantic.

trap, requiring less silk than most other kinds of webs. However, orb webs weather badly, losing their stickiness and therefore requiring frequent renewal, although this is helped by the fact that many species are able to roll the web into a ball and eat it, thereby recycling the nutrients.

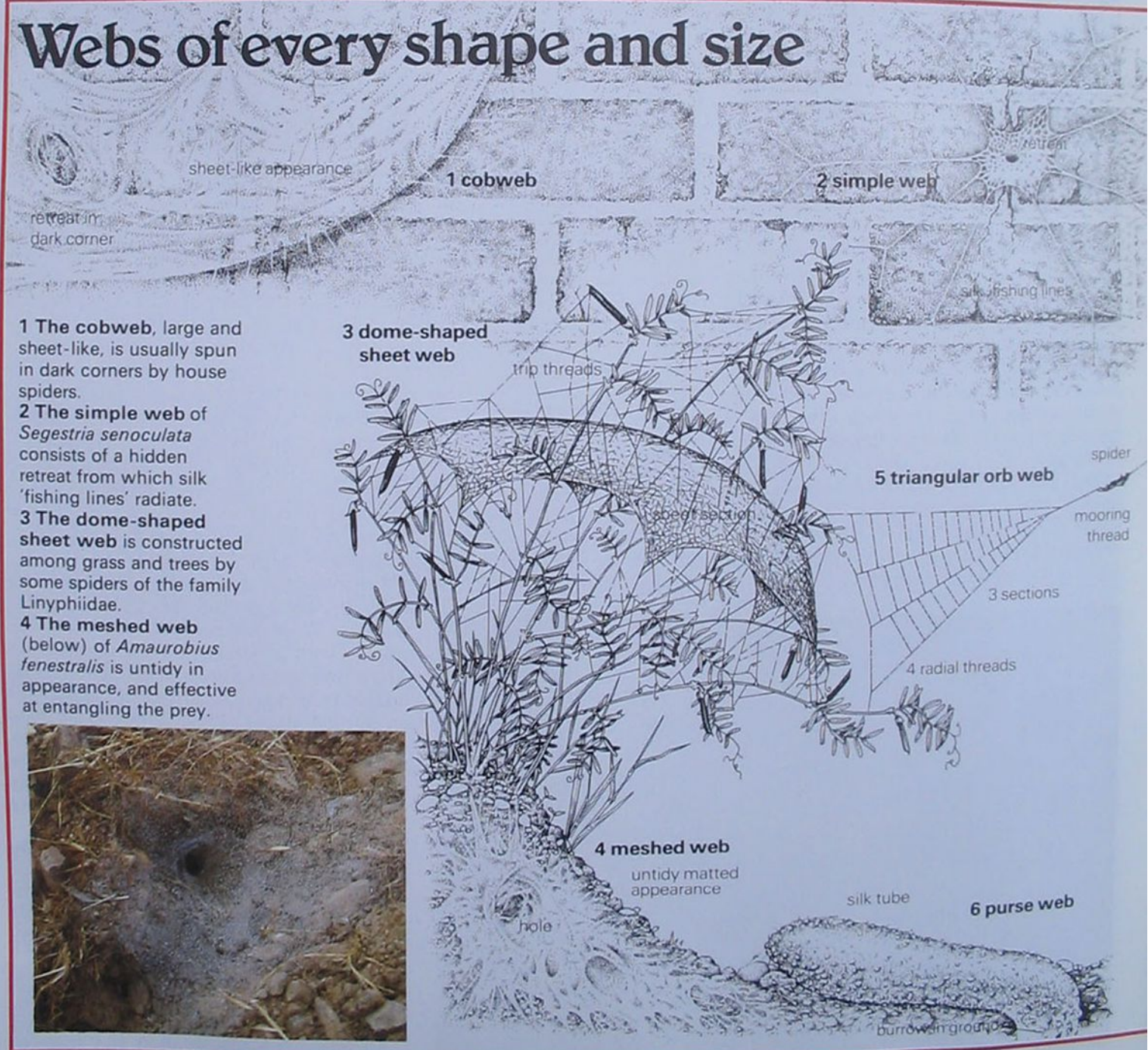
There are many species of orb web weavers (families Araneidae, Tetragnathidae and Uloboridae), but the garden spider (*Araneus diadematus*), recognised by the cross marking on its abdomen, is the best known. Other orb web spiders range from the large and colourful species *Araneus quadratus*, which can be red, brown or yellow, to the smaller, bright green *Araneus cucurbitinus*, which builds its orb web in the curl of a leaf.

An orb web contains between 1000 and 1500 connected points, mostly of radii and spiral threads. The number of radii is constant for each species, hence the web of the garden spider has 25 to 30 radii, that of *Tetragnatha extensa* has about 18, and that of *Mangora acalypha*, between 50 and 60.

Miscellaneous webs In the family Uloboridae, which is more closely related to the Amaurobiidae (meshed web builders) than to the Araneidae and Tetragnathidae (orb web weavers) the webs show some unusual features. That of the rare southern species *Uloborus walckenaerius* is horizontal and comprises 30 to 40 radii, but instead of fixing sticky globules to the spiral (as is done by most orb web weavers), the spider spins threads of calamistrated silk. *Uloborus walckenaerius* lacks poison glands; thus when the prey becomes entangled in the web it is not bitten but simply immobilised by being wrapped in silk.

While the orb web of *Uloborus*

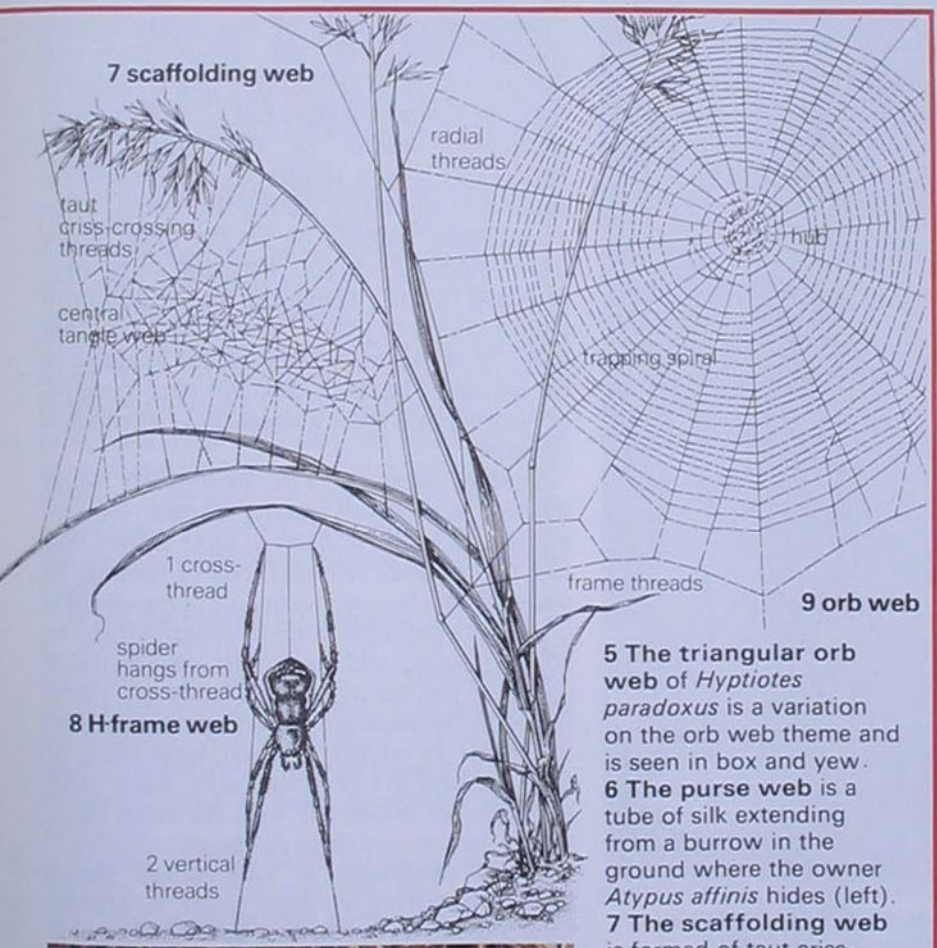
Webs of every shape and size



1 The cobweb, large and sheet-like, is usually spun in dark corners by house spiders.
2 The simple web of *Segestria senoculata* consists of a hidden retreat from which silk 'fishing lines' radiate.
3 The dome-shaped sheet web is constructed among grass and trees by some spiders of the family Linyphiidae.
4 The meshed web (below) of *Amaurobius fenestralis* is untidy in appearance, and effective at entangling the prey.

Right: An orb web essentially comprises three elements: a number of **radial threads** (25-30 on the web of *Araneus diadematus,* shown here) converging on a central spot, the hub; **frame threads** which delineate the web and serve as insertion sites for the radials; and the **trapping spiral** which is the only sticky element.

Below right: The orb web spider *Araneus quadratus* waits on the side of the web, with a couple of legs resting on the line, so it can feel the vibrations made by any creatures landing on the web.



5 The triangular orb web of *Hyptiotes paradoxus* is a variation on the orb web theme and is seen in box and yew.
6 The purse web is a tube of silk extending from a burrow in the ground where the owner *Atypus affinis* hides (left).
7 The scaffolding web is formed of taut criss-crossing threads which stretch above and below a central tangle web where the owner, *Steatoda bipunctata,* hangs.
8 The H-frame web of *Episinus angulatus* usually has two vertical threads joined by a cross-thread.
9 The orb web, built by, among others, *Araneus* species, is a two-dimensional structure, and the most highly evolved of all webs.

walckenaerius forms a complete circle, the web of the related triangle spider (*Hyptiotes paradoxus*) is triangular and much reduced. Four radial threads, enclosing three sectors, converge on one mooring thread at the apex. The body of *Hyptiotes paradoxus*, which is brown and rather lumpy, bridges a gap between the mooring thread and another strand attached to a twig. When an insect is caught, the spider pulls the web taut, and then lets it go slack again to entangle the prey further. A new web is built after each catch.

Interesting webs are built by *Episinus angulatus* and *Episinus truncatus* (family Theridiidae). The type of web built by these spiders shows an extreme reduction from the usual theridiid scaffolding web, with just two vertical threads joined by a cross-thread (H frame), from which the spider hangs. Sticky droplets at the bottom of each thread adhere to insects when touched, and the spider lifts the insects clear. Ants, usually rejected by most spiders, appear to form the main prey.

Silken tube The purse web of *Atypus affinis* is in a class of its own. A tube of silk, like the finger of a glove, extends from a burrow in the ground, excavated by the spider in areas of light soil. This pale greenish species lives inside the tube and, with its huge fangs, bites through the web fabric to transfix any insect which alights on the surface. Slicing a hole sufficiently large to pull the prey through, the spider repairs the damage later.

SQUAT LOBSTERS AND MUD SHRIMPS

Among the lesser known crustaceans of our coastal waters are squat lobsters–tiny creatures that 'flap' their tails in alarm when discovered. Mud shrimps, too, are rarely seen for they spend their lives in long burrows in mud and sand.

Above: A vividly coloured specimen of *Galathea strigosa*, seen in the resting stance. The fifth pair of legs is reduced in size and lies along the margin of the shell, out of sight. These small legs are used for cleaning particles out of the gill chamber, and carry hook-shaped hairs for the purpose. They are also used to clean the shell surface and antennae.

Left: Montagu's plated lobster (*Galathea squamifera*).

Squat lobsters are marine crustaceans and are so named because they look like short, squat, miniature lobsters, although in fact they are not closely related to the common lobster. Various species of squat lobster inhabit the waters surrounding Britain and Ireland, but of these only Montagu's plated lobster is ever abundant on the shore.

The bodies of squat lobsters are flattened dorsally (they are broad but low in profile) and the 'tail' or abdomen is carried tucked beneath the body. When a squat lobster is at rest, its three pairs of walking legs are spread out. Each leg terminates in a sharp claw that can grip surfaces with surprising strength, preventing dislodgement by waves or water currents. When disturbed, squat lobsters swim by a vigorous beating of the abdomen that has earned them the name 'flappers' in some regions. Swimming can be sustained for only short durations.

Main species Five of our squat lobster species belong to the genus *Galathea*. *Galathea nexa*, *G. intermedia* and *G. dispersa* occur in offshore waters but *G. strigosa* is an occasional visitor to the lower shore. Montagu's plated lobster (*G. squamifera*) is sometimes abundant during the spring, when populations migrate on to the lower shore from offshore waters. Females carry eggs attached to the swimmerets of the abdomen from January to May. The minute larvae that hatch from these are very similar in shape to the larvae of hermit crabs and mud shrimps, suggesting that these animals have a common ancestor.

Feeding methods The biology of squat lobsters is relatively poorly known. Observations of *Galathea dispersa* have shown that this species uses two methods of feeding. In one of these the outermost pair of mouthparts is used as a pair of brooms to sweep surfaces to collect detritus and algae. The small particles collected on the mouthpart hairs are transferred to the innermost mouthparts and then to the gut. In another method, large pieces of food are held in one of the claws, while small portions are pulled off with the other claw, which then passes them to the mouthparts.

Ritual challenges A long-clawed plated lobster occurring in deep water is *Munida sarsi*. Studies have revealed that this lobster is not the quiet and solitary animal as once supposed, but displays a characteristic aggressive ritual to defend its territory where it digs and feeds. Observations on specimens in captivity have shown that an individual lobster threatens an approaching intruder by raising its abdomen, extending its claws and snapping them menacingly. Sparring often occurs, and sometimes one squat lobster grasps its opponent's claws. Combats usually end when one contestant jerks itself free, and swims backwards by flapping its abdomen, retreating in the screen of mud stirred up during swimming. Such conflicts are apparently harmless. The long claws seem

important for inciting this behaviour, for it has been noted that lobsters that have lost both claws are ignored by the others.

Mud shrimps These form another group of crustaceans that are not frequently observed. Only two of the nine species of mud shrimps occurring around Britain and Ireland are likely to be discovered on the shore, and these are found at the lowest part, around the low tide mark. Their capture involves much laborious digging of the mud surface. Mud shrimps are specialised for living within burrows, which they construct below mud, or muddy sand surfaces. These crustaceans have relatively soft, nearly cylindrical bodies. Two conspicuous features are the very unequal claws projecting at the front and the long swimmerets carried beneath the segmented abdomen.

Because of their subterranean habits, mud shrimps are difficult to observe, even in captivity. However, by confining them in very narrow, mud-filled aquaria, researchers can watch their movements through the incomplete burrows that they build in such restricted conditions, with the aquarium glass forming part of the walls.

Active tunnellers Burrow making is a constant occupation of mud shrimps. The large claws and the following two pairs of legs are used for digging and scooping mud towards the mouth, where it is raked into a 'basket' formed by hairs lining these anterior limbs. The shrimp usually begins its burrow by digging a nearly vertical hole about as deep as its body length. It backs out with each load of mud, and deposits it at the entrance. It then makes a large cavity at the base of this hole, which functions as a 'turn around'. From here the shrimp continues to burrow at a shallower angle.

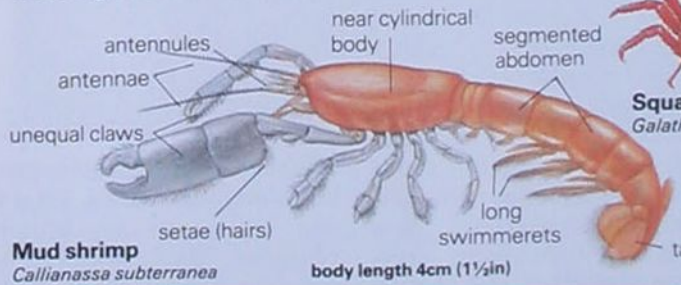
When the burrow is complete, it consists of a system of tunnels with two or more entrances. The animal lies inside the burrow and creates a ventilating current by beating its swimmerets. Once established in a burrow, a mud shrimp defends the entrances against any intruders, using its large, prominent claws if necessary.

Feeding method Mud shrimps, like squat lobsters, feed upon detritus, and repeatedly sift mud through the hairs covering their anterior limbs. They have also been observed feeding at the entrances to their burrows. They form a 'basket' with the first and second pairs of legs, and set water in motion along the burrow by increasing the beating rate of the swimmerets. Particles are strained from the water and drawn into the 'basket'; at intervals, the external pair of mouthparts combs the inside of the 'basket', removing trapped particles and passing them forward to the mouth.

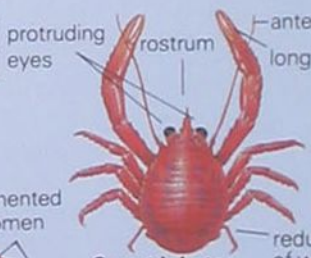
Ancestral link The minute larvae of mud shrimps are very similar to those of squat lobsters, suggesting a common ancestry. Larvae of *Jaexa nocturna* frequently occur in the plankton and can be recognised by the elongated head region and conspicuous eyes. Although mud shrimps have adopted a specialised life-style, they occur in considerable numbers in some regions, and their burrows extend over large areas. In many respects they have been perhaps more successful in exploiting the sea-bed than their relatives, the squat lobsters. They have evolved a wide range of species, and are thought to occur in greater individual numbers.

Above: *Munida sarsi*, seen off the Hebridean island of Coll. Between the widely spread claws you can see the external pair of jointed mouthparts. The animal is about 6cm (2½in) long.

Recognition features



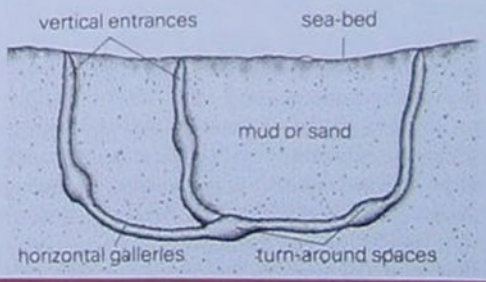
Mud shrimp
Callianassa subterranea
body length 4cm (1½in)



Squat lobster
Galathea intermedia
reduced fifth pair of walking legs (often carried underneath edge of shell)

The burrow of a mud shrimp

Vertical entrances are connected by galleries with turn-around spaces. Inside, the mud shrimp sets up a ventilating current by beating its swimmerets. It also continuously repairs or improves the burrow, building new tunnels.



A deciduous wood is one of our most complicated habitats, and exploring it in search of wildlife is a challenging exercise for any naturalist.

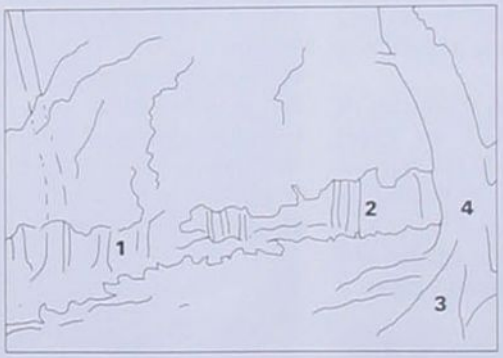
Deciduous woods really consist of three quite separate layers: the ground layer, above that the field layer, and higher still the tree or canopy layer. The ground zone includes not only living plants but also the all-important leaf litter, while the field zone embraces everything from 15cm (6in) to 2m (6ft) above the ground, for example bracken, bramble, low thickets of elder and so on. Above that is the tree layer. Each of these three layers provides its own special blend of food, shelter, breeding sites and other resources for wildlife.

Getting ready Before plunging into the wood, there are a few points you should bear in mind. Because trees are constantly producing moisture, woods are chilly, damp places, even in mid-summer. Warm clothing is essential–all the more so because woodland, perhaps more than any other habitat, demands patient sitting and waiting before you will see its shyer inhabitants.

Even in drier woods, heavy night dew can make the vegetation quite wet, and wellington boots are often useful. They will also protect you against prickly brambles and other obstacles. Hats, however, are generally a nuisance, being too easily knocked off by branches. Moreover, anything that covers the ears seriously reduces the immense amount to be learned in woods simply by listening.

Watching is, of course, aided by a pair of binoculars. When the trees are in full leaf and the light dim, it is best to use a pair that gives you a bright image, such as 7×50s–the '50' signifies that the lenses furthest from your eyes are each 50mm (2in) wide and thus have excellent light-gathering properties.

Beechwood in autumn With this basic



Making a start

You have several options in a patch of woodland like this. (**1**) Shake the leaves and catch falling insects. (**2**) Move away from the track to look for undisturbed flowers and areas where deer lie up. (**3**) Search the bases of trees for mammal holes. (**4**) Hide and wait for animals to appear.

Above: This ashwood in Ross-shire demonstrates the great range of habitats found in a deciduous wood.

Right: Throughout much of the spring and summer many insects, especially the caterpillars stages, remain well hidden among the foliage of trees and shrubs. The best way to catch these insects is to shake the bough while holding an upturned open umbrella underneath to act as a net for the falling insects.

equipment there is a great deal that you can discover. The best time to start is perhaps late autumn or winter when the pace of life slows down and the bareness of the trees makes it easier to spot things.

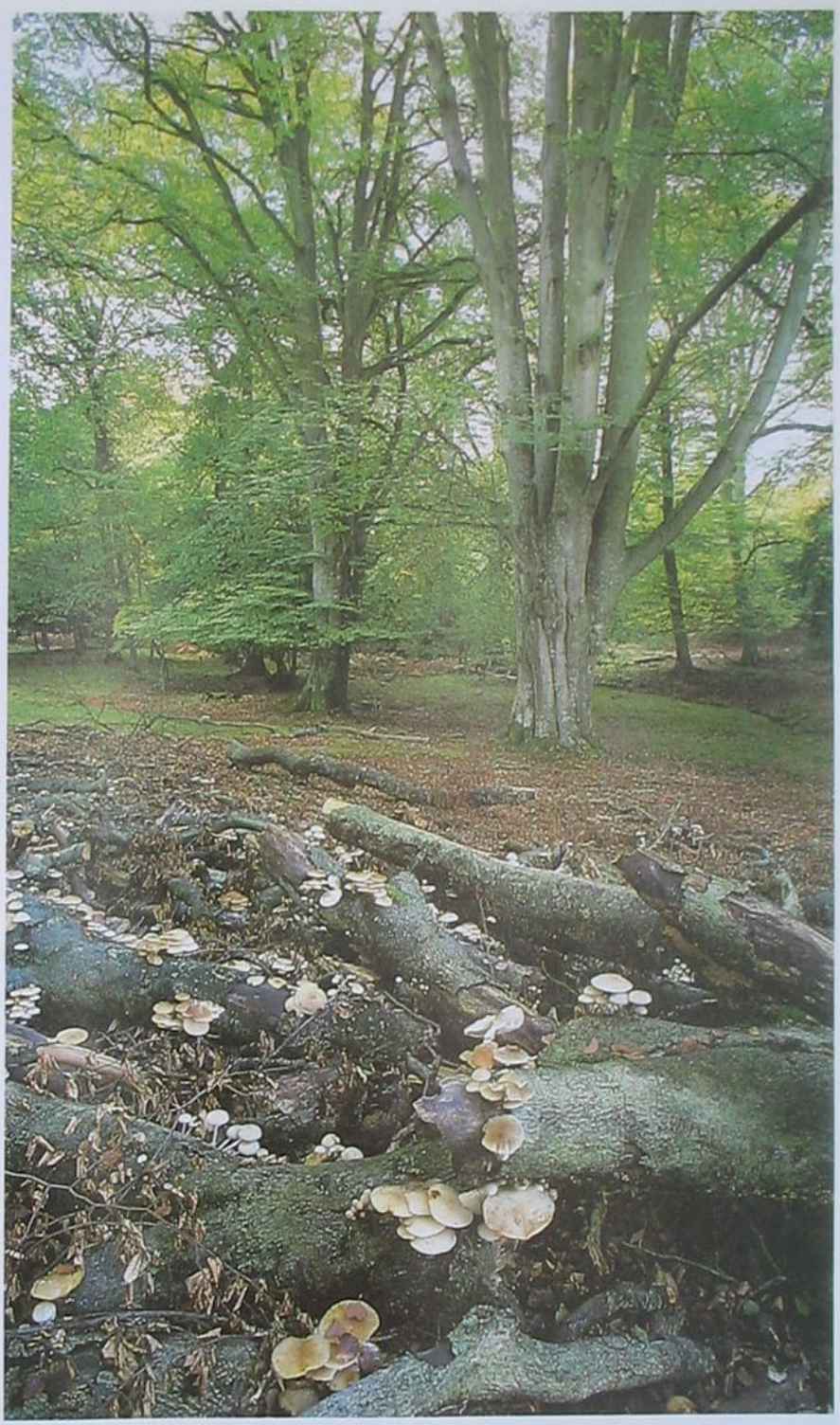
A rewarding place to visit is a copse of mature beech, especially if it has been a seeding year and the trees have produced a bumper crop of nuts. These are a source of food much prized by many birds and mammals.

Note that the oldest beeches are often host to bracket fungi. Indeed, there are numerous different species of fungus associated with beech. Some grow on the tree itself while others grow among the leaf litter below. Many fungi are restricted to either deciduous or coniferous woodland, and a few are even found only in association with just one or two species of tree – a fact that makes identification of fungi sometimes very much easier. The beechwood sickener, for example, with its striking red cap, is found only in beechwoods – as its name suggests.

Although autumn is by far the best season for fungi, remember that some appear at other times of the year. Velvet shanks, for example, flourishes on stumps and trunks throughout the winter.

Insect hunting Many invertebrates like a dark moist habitat, so at any time of the year it is worth probing into clumps of lichen or mosses, and searching the crevices of bark for resting insects. Some, such as the tiny springtails, are too small to see properly with the naked eye, so use a hand lens to observe them. Look, too, under loose bark for creatures such as snails, millipedes and woodlice. Remember, however, that the subtle conditions offered by these refuges are easily disrupted when exposed, so always explore them gently. By day, all these creatures are likely to be rather inactive, but a look at the trunk at night (with the aid of a torch) shows it to be supporting a teeming traffic of foraging insects, spiders and so forth.

Rotting logs support an exceptionally rich community of plants and animals. The first invaders of a stricken tree are often bark beetles. Their mining activities admit a host of other creatures and plants, and many foresters now recognise the intrinsic value of fallen



Above: Some fungi are found only in association with a few species of tree, or occasionally even just one species, a fact that can make identification very much easier. Beech tuft, for example, is a common fungus found on no other tree but beeches. This, plus its characteristically semi-translucent, slimy appearance makes it an easily identifiable fungus. It appears in summer and autumn on dead and decaying beech wood (as here) and on living trunks.

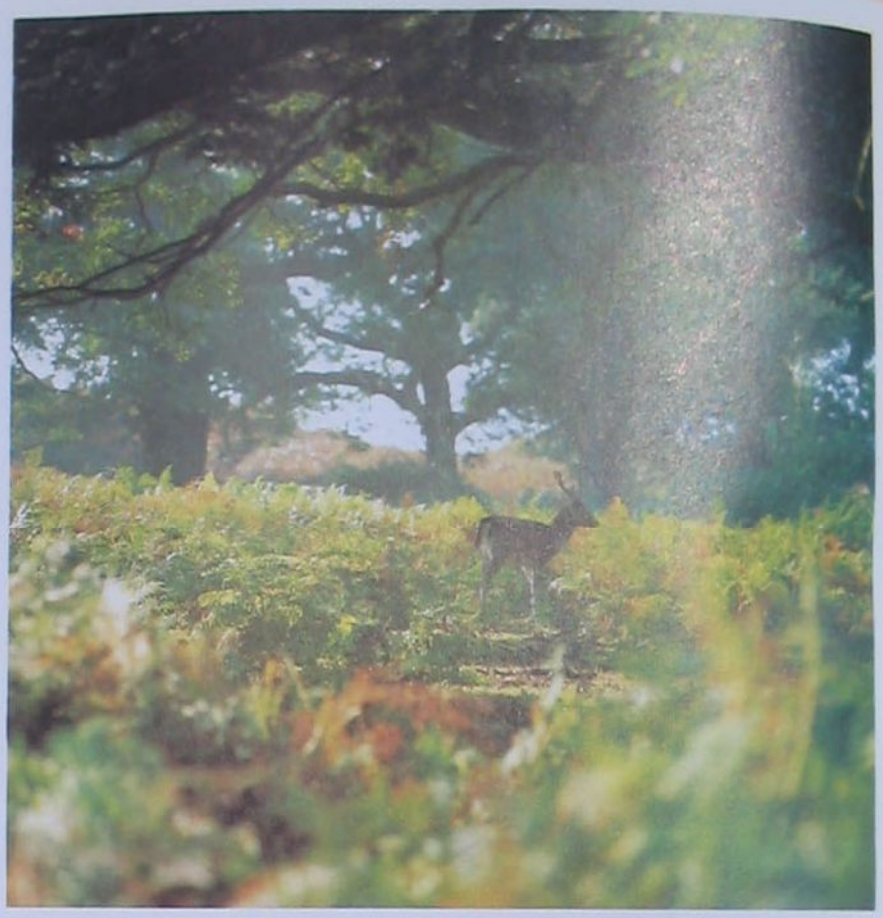
timber as a habitat. Instead of tidying it up, as they used to do, they now leave it to be colonized.

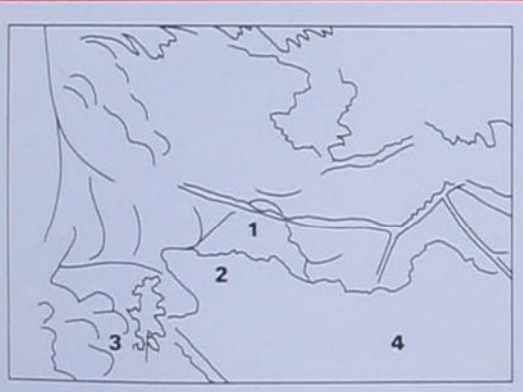
Spring flowers Early spring offers the best opportunity for spotting many species of woodland flowers, such as wood anemone, wood sorrel and primroses, which thrive on the sunlight filtering through the still-bare branches. Take care, however, not to trample the bluebells, even if they have finished flowering. The fleshy leaves continue to manufacture vital foods for the plants long into the summer.

Though it is not one of our most attractive plants in flower, dog's mercury is often the most prolific plant in southern woodlands, spreading a uniform carpet of green over the floor.

Birdwatching Given a particular geographical location of a wood, the kinds of trees, their age and how openly they are planted, one can make a fair guess at the sorts of birds that might live there. Hawfinches, for example, are often associated with hornbeams because they supply a suitable diet of seeds in the autumn. You will, however, have to be extremely patient–and very lucky–to spot a hawfinch, it is one of our shyest birds.

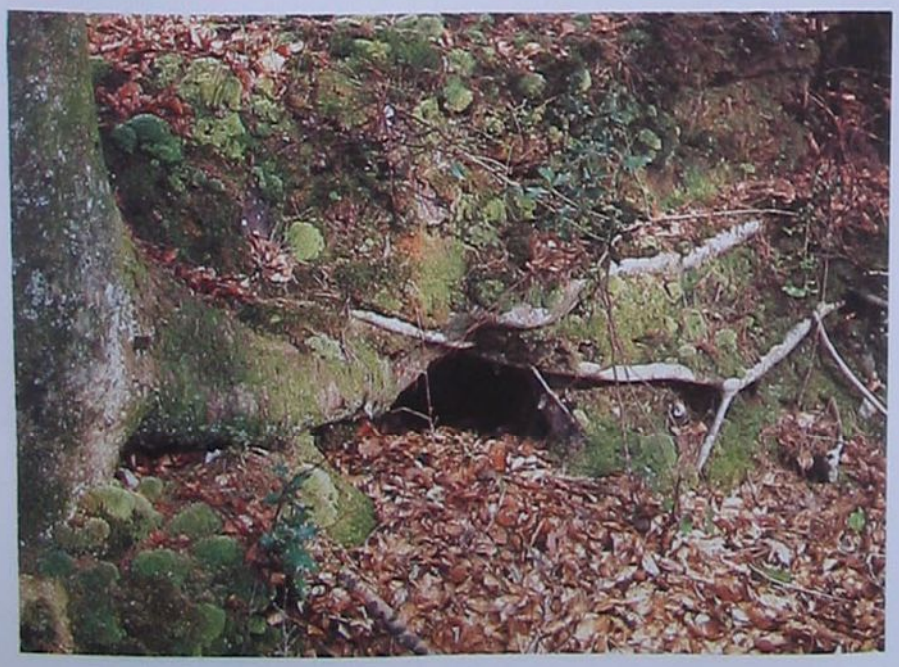
Unfortunately, few associations are as specific as this. Nevertheless, one can make some useful predictions. Woodpeckers like mature stands of trees with lots of insect-ridden timber. On the other hand, birds that hunt on the wing for insects–such as redstarts, pied flycatchers and nightjars–prefer more open deciduous woodland, while jays, nightingales and wrens all demand a dense shrub layer.





Investigating banks

Holes in a bank (**1**) can be made by fox (usually smell musty; about 20cm/8in across) or badger (about 35cm/14in across). Look outside entrance (**2**) for bones (fox) or grass sweepings (badger). Look among clumps of moss (**3**) and leaf litter (**4**) for invertebrates.



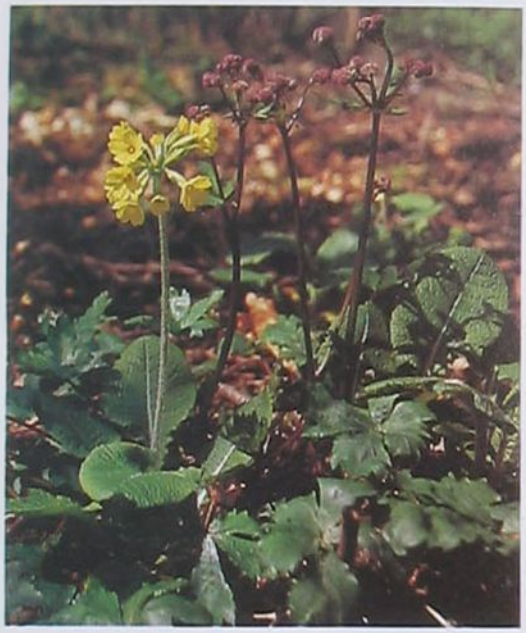
Listening to birds In spring, birds are busy advertising themselves, notably by song, and it is a great advantage if you can become familiar with these songs. Although some of the record albums of bird songs–such as those produced by the BBC and the RSPB–are wonderful aids to identification, in the end the unfamiliar songs must be distinguished in the wood itself. The best procedure is to locate the songster and stealthily approach until you get close enough to identify it by its appearance. With practice, the song eventually becomes the only clue you need.

From January through to May, one of the most typical sounds of the wood is the monotonous see-sawing phrase of the great tit. More often heard than seen is the jay, whose coarse rasping call resembles the sound of stiff canvas being torn, while woodpeckers can be detected by their drumming on hollow, resonant trunks. A prolonged bout of loud, insistent drumming is the hallmark of the great spotted woodpecker. Its smaller cousin, the lesser spotted, drums much more lightly, while the green woodpecker scarcely drums at all and is more likely to be found at the woodland's edge.

From spring onwards, there is a steady

Left: Deer are very shy, wary animals, and not easy to see. In an English wood, you are most likely to come across a fallow deer (as here), though in more southern parts the muntjac is on the increase. In Scotland, however, you are more likely to find a roe deer.

Right: A careful look among the tree canopy may reveal a sleeping tawny owl close to the trunk of a tree.



Left: Oxlip and sanicle flowering in a coppiced wood in April. Many flowers of deciduous woodland appear early in the year before the leaf canopy casts its dense shade.

Below: The entrance to a badger sett. If you settle down a little way off and wait for sunset, you may be rewarded with a sight of the badgers emerging.

influx of migrants to add to the chorus of birds. The first arrival, at the end of March, is a small warbler whose repetitive 'chiff-chaff' call lends the bird its name. It is a valuable exercise to build up a seasonal chart of songsters, because it will tell you a great deal about the territorial behaviour of birds. Robins stake out winter territories and therefore sing vigorously in August and September when most birds are silent. Tawny owls hoot for their territorial rights from October onwards, which makes a foray into deciduous woods during an autumn night well worth your while.

Traces of mammals Late evening is the best time for catching a glimpse of badgers, foxes and perhaps deer as well. In summer, the chances of seeing badgers are greatly increased by first finding their underground setts, usually sited well away from footpaths, most likely in a bank. Sometimes it can be difficult to distinguish a sett from a fox's earth, especially as the two may exist in separate parts of the same burrow system. However, while foxes discard their excavated soil in a fan-shaped ramp immediately below the entrance, badgers deposit theirs a short distance away, often leaving a tell-tale gully in front of the entrance.

Although seeing deer is usually a matter of chance, for they are extremely shy, wary animals, if you can find some of their feeding signs then a quiet vigil at dusk or dawn may see them returning to familiar ground. For this, a field guide is a most valuable asset.

In dense undergrowth you may hear the shrill squeaks of angry shrews as they run into one another and contest territorial rights. They leave few tangible signs of their presence, but experienced trackers can distinguish their tiny oblong droppings, typically crammed with insect remains.

Meal leftovers Some birds and mammals can be identified from the leftovers remaining from their meals. For example, the way in which a hazel nut is broken into, to extract the kernel, gives a clue to the creature feeding on it: squirrels split the nuts neatly in half, wood mice gnaw a neat circular hole in one side, and great tits hammer a small squarish hole.

Often the most puzzling finds in woods are the kills of predators, but these too leave clues. A mass of feathers by a bush or low branch shows where a fox has pounced on a roosting bird, and sparrowhawks bite off the heads of their prey. Such remains are often easiest to find in winter; in summer the prey is more likely to be dragged away to hungry offspring.

THE LONDON THAMES

London's Thames hemmed, in by a desert of stone and concrete, looks murky and lifeless but actually has a wealth of wildlife interest.

If you stand on London Bridge and look over the parapet, the Thames slides by beneath, its water greeny-brown and carrying pieces of driftwood and plastic cups and bags–the flotsam of a busy urban river. The Thames here is a working river, with tugs towing lighters carrying timber, fuel and London's rubbish and, in summer, passenger launches packed with tourists. Running between constricting stone walls for much of its length, with the buildings of London rising all around, the river can look devoid of life.

These days, however, the Thames is not a dead waterway but a living one, full of wildlife interest. Part of its attraction is that it is always changing. Being tidal, it is sometimes so high that it is within feet of the top of the bankside flood defence walls when fresh water from recent rains on the Berkshire Downs and Chilterns roars downstream to meet the high tides running up from the sea. Nevertheless, only three or four days later the river will be flowing placidly and smoothly again, with extensive gravel and mud banks left on either side of the water.

Moreover, as it meanders along no two reaches are ever quite the same in appearance. Downstream from Teddington to Richmond

Above: The Thames from Richmond Hill in autumn–at this point the river bed is mostly gravelly and the banks are grassy.

Right: Black-headed gulls in winter, dabbling in the river mud at low tide.

Below: A haddock–this species has been caught in the Thames off Barking in recent times. Whiting, too, are now common and even mackerel have been found.

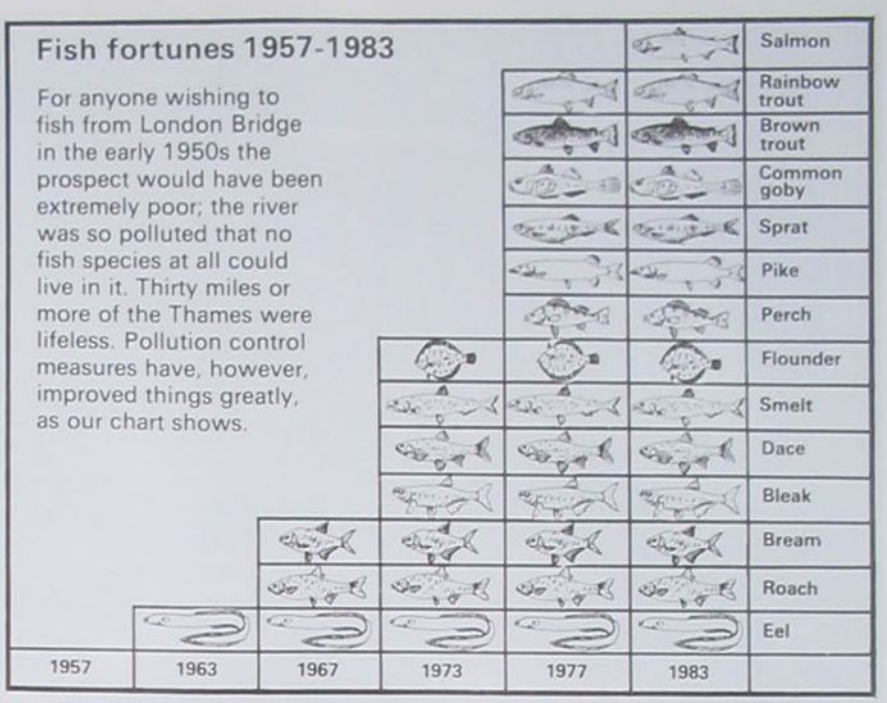
the river has a natural aspect: the banks are grassy, trees grow close to the river's edge and the river bed is gravelly for the most part (but muddy on the bends). Small islands, or aits, break the river's gentle flow and offer sanctuary to aquatic animals which thrive out of the current, at the same time providing shelter for water birds and insects. Below Richmond Bridge the river has an idyllic quality, with Kew Gardens on the south bank and the almost wild banks of Syon Park on the north.

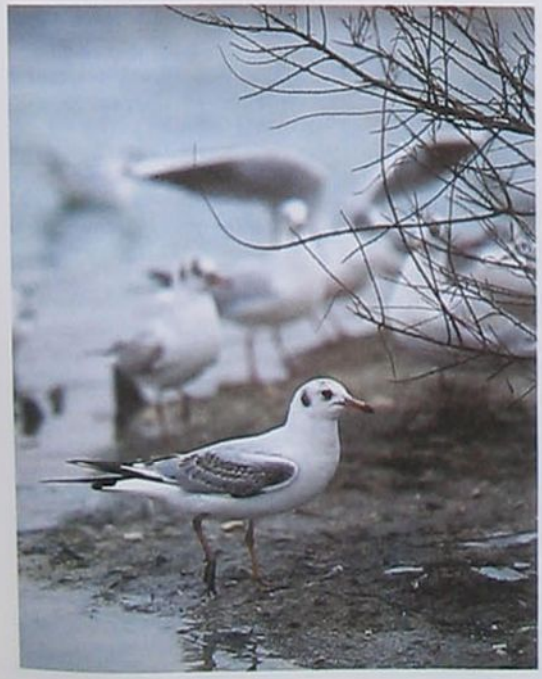
Below Kew Bridge the river tends to become busier, with pleasure boats and private craft; through Mortlake, Corney and Chiswick reaches the banks are increasingly man-made, although grass and trees make a natural border to the river itself. Buildings and roads begin to intrude into the background from here downstream. From Wandsworth Bridge the river banks are increasingly artificial and the river bed becomes muddier, with occasional exposed gravel banks.

Just downstream of Barking Creek, at the mouth of the Essex River Roding, the great sewage works of Beckton on the north bank and Crossness on the south pour millions of gallons of highly treated sewage effluent into the river. Here, where the wealth of land allows a wilder landscape, the river wall dominates the view; beyond it the landscape is increasingly flat as the estuary of the Thames begins.

Thames tides In the London area the Thames is dominated by the sea, the rise of the tides causing the river's water to be ponded back and the fall providing constantly varying glimpses of the edges of the river bed. Twice a day, approximately, the tide falls so that the river water can flow directly to the sea, but just as frequently it is pushed back on the flow of the tide. At the neap tides, when the sea water rises and falls less, the ponding back is less noticeable than at spring tides. Even the spring tides vary in level with the seasons, from the strong movements at the equinoxes to the moderate tides of mid-summer and mid-winter.

The tidal nature of the river has a bearing on all aspects of its natural history and its use by man. For one thing, the amount of salt in the water varies with the state of the tide and with upland flow (fresh water coming downstream). As fresh water is less dense than sea water the fresh water will form a wedge, and flow downstream on the surface of the sea water which, also wedge-like, flows upstream. But the course of the tideway is so irregular,





Although fishes have stolen the limelight in accounts of the recovery of the London Thames–partly because they are entirely dependent on the quality of the water–there have been dramatic changes in other animal populations. As the condition of the river improved in the 1970s, large numbers of pochard (above) and mallard moved into the Woolwich area in winter. At Barking flocks of mallard, teal, pintail, tufted duck, shelduck, dunlin and redshank were numerous during the 1970s, evidently attracted to the rich feeding offered by the small tubifex worms (right) that were so abundant on the foreshore. Many of these species also occurred upstream, although in smaller numbers, and at times it has been possible to watch small flocks of teal and tufted duck within sight of the Tower of London.

Above: A view over the Thames to Wapping. East of the City the once busy docks are now largely wastelands, providing temporary refuge for plants and wildlife, and the river-side is steadily industrial, with factories and electricity generating stations.

with something like 25 sharp bends between Teddington and the sea, that fresh and sea water become thoroughly mixed, and the salt content gradually increases towards the sea. This means that animals which favour low salinity water can choose the area in which they prefer to live to give them minimum exposure to adverse conditions.

This is illustrated by the distribution of various species of small oligochaete worms. Near Wandsworth Bridge *Tubifex tubifex* is dominant in numbers, downstream this species and *Limnodrilus hoffmeisteri* are dominant at London Bridge, and down at Woolwich a third species, *T. costatus*, is numerically dominant. These worms are important food for several fish species when the tide is in, and for ducks and waders when it is out.

The tidal nature of the London Thames has caused problems, however. There was always the possibility of flooding when high fresh water flows coincided with spring tides and strong northerly winds over the North Sea–this is why the Thames barrier has been built at Woolwich. Another problem is that, due to its tidal nature, anything put into the water in London does not simply wash downstream but is carried up and down the river at the mercy of the tides.

River pollution The tidal nature of the river was ultimately the cause of pollution in the River Thames, which resulted in it becoming a lifeless river over much of its length for many months of the year in the 19th century and again in the 1940s and 1950s. As London grew, most of the waste from its industry, slaughterhouses and fish market, and sewage found its way directly or indirectly into the Thames. Organic matter of this kind decays by bacterial action in water, using oxygen dissolved in the water in the process. As a result there is less oxygen available for fishes and invertebrate animals. In the 1860s the river was practically lifeless and it smelled vile as well.

As a result of public concern about the state of the river, mainly as a threat to health, a major new drainage system was built which took most of the sewage eastwards of London, to Beckton and Crossness where, after treatment, it was discharged into the river. However, the river is tidal there, too, and the result was mostly just to move the worst pollution downstream from central London to the vicinity of Barking and Woolwich.

With short-lived improvements, as different methods of treatment were tried, the Thames was in a poor state during the 1920s and 1930s, but by the 1940s and 1950s there were some years when as much as 48km (30 miles) of river were absolutely lifeless. The concern for public health led the London County Council and the Port of London Authority to initiate a huge rebuilding scheme

The London Thames (taken here to be the section from Teddington Lock to a point just east of Barking) is a tidal river, constricted by stone or concrete walls and lined for much of its route with industry, sewage works, power stations and docks. Among the wild creatures found in, on or near the river are dace (**1**), teal (**2**), pintail (**3**), salmon (**4**), redshank (**5**), mackerel (**6**) and flounder (**7**). The migratory species are among the most exciting fishes in the London Thames. Between 1979 and 1982 nearly 200,000 young salmon were put into suitable tributaries. Many of them travelled downstream to the sea and returned, for the first time in any numbers, in autumn 1982, when over 100 salmon were captured, mostly at Moseley Weir.

Below: A mallard duck with her family of ducklings. That these, and many other, birds can survive on the Thames today is evidence of how successful the cleaning-up operation has been. The Thames was the first river in this country to be treated in this way and it formed an example to the world. The Thames is London's biggest open space and it is also probably London's richest wildlife habitat. For instance, common terns can now be seen on the river, especially downstream from Woolwich, and it is not an unusual thing to see two or three of these birds diving for small fishes, probably young sprats but possibly gobies too.

at the major sewage works, improving the treatment of sewage while at the same time closing many small, rather inefficient works in the London area, and to control strictly the discharge of polluting substances into the river.

In the late 1950s freshwater fishes could be found in the tideway only between Teddington and Hammersmith Bridge, while sea fishes occurred upstream only as far as Gravesend. There were no fish for the middle 48km (30 miles) of the river, and this also applied to many of the aquatic invertebrates, particularly the crustaceans and insect larvae. Few birds could be seen on the river then, except for foraging gulls, occasional mallard and mute swans.

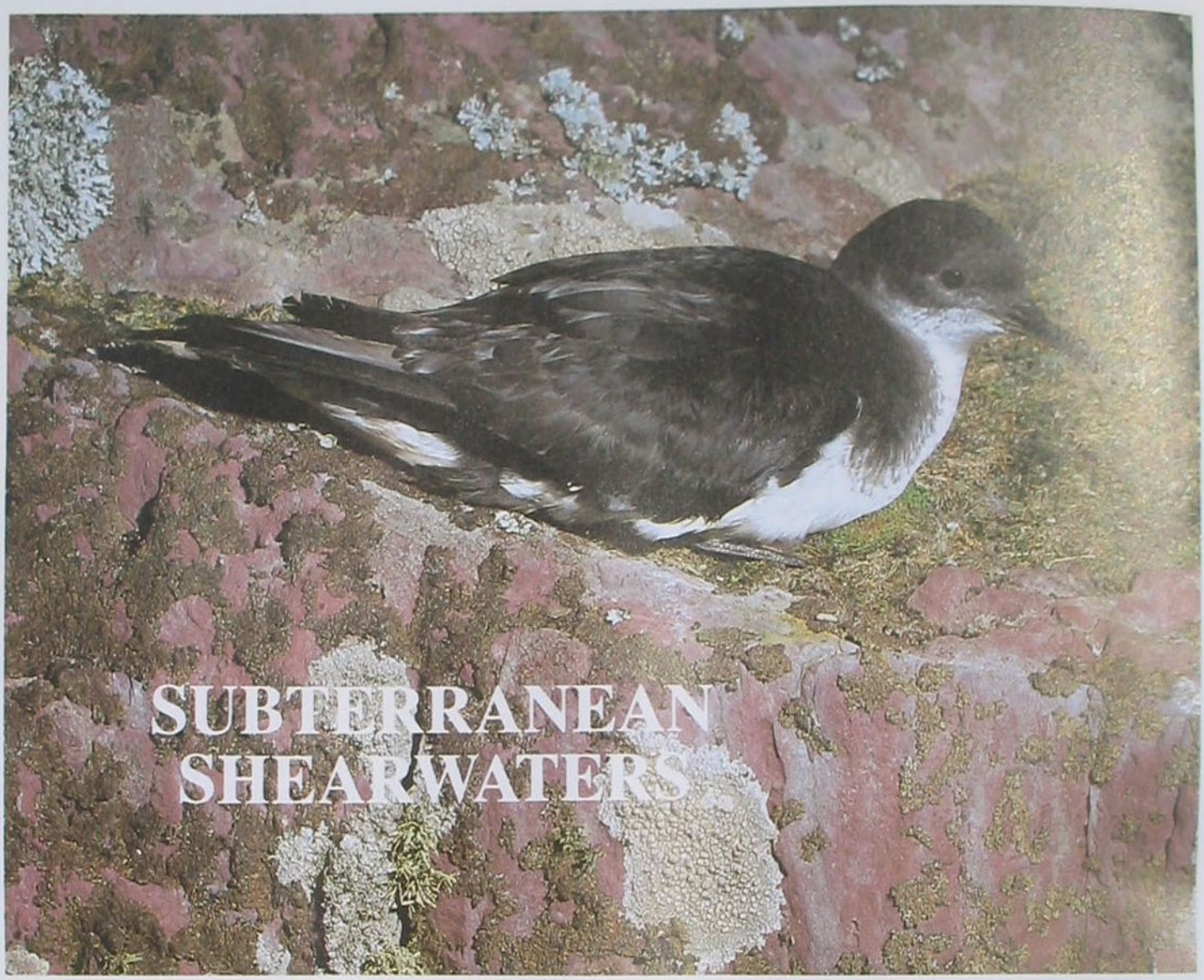
By the mid 1960s the new pollution control measures and the better treatment given to the sewage had caused the condition of the water to improve. More oxygen was present in the water and fish began to reappear.

Thames fishes Downstream, sea fishes such as tadpole-fish, sand eels, gobies, pipefish and smelt were caught between 1964 and 1966, while upstream roach were captured near Wandsworth Bridge in regions where no fish could be found a decade before. Then for the next 10 years more and more fishes appeared, and in greater numbers, until by 1981 over 100 different species had been captured in the tidal river from Teddington to Southend.

Upstream of London freshwater fishes dominate. In the 1970s roach and bleak were most abundant, but dace, bream, carp, tench, pike and perch all occurred frequently. More recently roach seem to have become less common and dace and bleak dominate the upstream reaches. Rainbow and brown trout also occur.

Downstream of London sea fishes are dominant, but their numbers fluctuate with the seasons, and with the spawning success of the species in the North Sea. At various times young sprats and herring have been immensely abundant, some coming up as far as London Bridge. Flatfishes–plaice, dab, flounder, brill and sole–have all been caught in numbers downstream of London. Modest, but none-theless exciting, migratory fishes like smelt, flounder and elvers are now common all the way up the Thames in London–and salmon too, over 100 being caught in 1982.

Invertebrate life Perhaps because of the numbers of birds and fishes feeding on them, the mud-dwelling invertebrate population has changed considerably over the years, particularly the tubifex worms which occurred at one time in such abundance that the mud in places looked blood-red. Small shore-dwelling crustaceans and water snails are also common and form suitable food for both birds and fishes. It seems now that animal types and numbers in the London Thames are becoming stabilised and the river has probably fully recovered from the years of pollution.



SUBTERRANEAN SHEARWATERS

Manx shearwaters nest in burrows, and the sound of their wailing calls, coming from underground at dead of night, has inspired legends of trolls.

Manx shearwaters are slender-winged seabirds about the size of a small gull. As their name suggests, shearwaters at sea skim low over the water, occasionally touching and 'shearing' through a wave-top as they bank and turn. The wings are relatively long and narrow, in comparison with those of a gull, and in flight they are usually held at right angles to the body, with the leading edge held very straight. For much of the time the wings are stiff, and the tips are bowed slightly downwards.

The plumages of adults and young are similar; dark, oily black above, and white below. The boundary between dark and light comes roughly at water level when the birds are swimming on the sea; although apparently very conspicuous, this distribution of colour hides the somewhat vulnerable shearwaters well from predators such as gulls that approach from above, or large fishes approaching from below.

In flight, however, their plumage is conspicuous; together with the characteristic flight pattern, it makes them easy to recognise at all but the longest ranges. They fly fast and low, often vanishing from view in the wave troughs, which may cause some difficulty in spotting them; but then they bank and turn, first presenting a white undersurface, then black upperparts, to the birdwatcher.

Long-distance gliders At sea, shearwaters cover prodigious distances, and are masters of the art of energy-conserving flight. Most often, they fly in a long, shallow glide down and along the ocean wind, then suddenly turn into the wind, using it to gain a violent uplift at the expense of flight speed, before heading off downwind again in another long glide. Shearwaters are seen performing this spectacular type of flight as they pass along the coast, either on migration or, in the breeding season, on fishing excursions. They often fly in groups, usually in a straggling line.

They are most frequently seen off our south and west coasts. In summer they can be watched in the vicinity of any shearwater

Above: A Manx shearwater: the name 'Manx' refers to a historic colony on the Calf of Man. After centuries of breeding there, shearwaters were absent for 150 years, returning in the 1960s.

Manx shearwater (*Puffinus puffinus*). Summer visitor. Sexes alike. 36cm (14in).

colony. These are located on the Isles of Scilly, Lundy, Skokholm, Skomer, Anglesey, some of the islands off the eastern Irish coasts, and many of the islands off the rocky western Scottish and Irish coasts.

Island colonies Most shearwater breeding areas are on remote islands, often uninhabited or at most with just a few human occupants. Shearwaters are clumsy on land; they have powerful webbed feet, and their legs are situated close to the rear of their bodies–which makes them effective swimmers. However, this makes walking on land rather difficult for them. They can only drag themselves along at a painfully slow rate. As a result, they easily fall victim to marauding gulls.

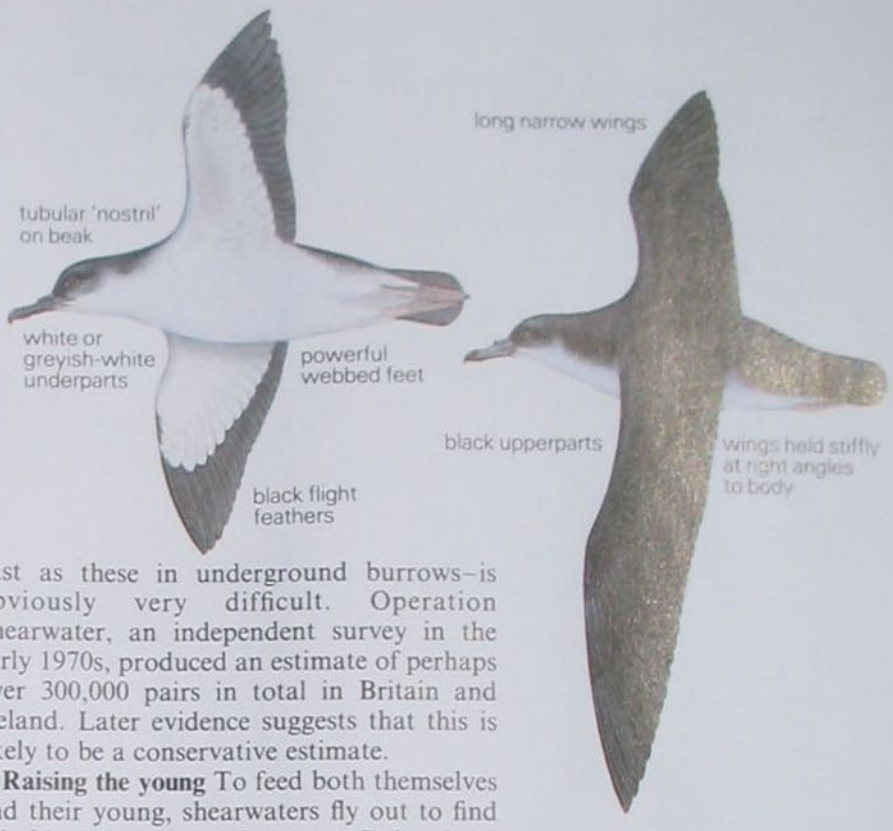
Greater black-backed gulls, in particular, specialise in catching shearwaters. It takes these large gulls only a couple of powerful bites to open the carcase and snip the wings off the shoulders. Then, with a few flicks of the gull's strong neck muscles, the shearwater is skinned and ready for eating. Around the nests of these predatory gulls, the discarded shearwater skins accumulate in a gruesome midden. Despite this vulnerability, shearwaters seem to be maintaining steady populations in most of the areas they inhabit.

As dusk falls, shearwaters gather offshore, floating on the sea in huge 'rafts'. They remain there for some hours, deriving a measure of safety in numbers, and venture ashore only when it is completely dark. Most colonies are on the cliff top, or close to the shore of low-lying islands. One striking exception to this norm is more than a mile from the sea and about 600m (2000ft) up on the rocky screes in the heart of the island of Rhum in the Inner Hebrides.

By day, anyone walking along the cliff top could be excused for not suspecting that there was a shearwater colony nearby. There is little outward sign of their presence in daylight except for the occasional carcase of a shearwater that fell victim to a gull the previous night.

At night, especially on a dark and stormy night, the scene changes dramatically. Homecoming birds fly past overhead with a rush of air, and call to their partners in the nesting burrows with extraordinary cackling, cooing and caterwauling calls. Those in the burrows make similar calls, and the sound of these, coming from the ground and after dark, has inspired legends. The troll legends of Norway, in particular, are said to have originated from these weird sounds.

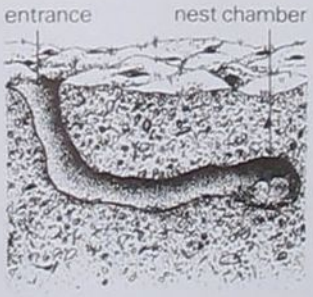
Shearwater numbers Shearwaters are always colonial, but while some new colonies may only hold a few dozen pairs, others are huge. The one on Rhum was estimated to contain over 100,000 pairs in 1976, while the one on Skomer was estimated at 95,000 pairs in 1973. Counting birds such as shearwaters–which have black upperparts, come ashore only after dark, and nest in numbers as vast as these in underground burrows–is obviously very difficult. Operation Shearwater, an independent survey in the early 1970s, produced an estimate of perhaps over 300,000 pairs in total in Britain and Ireland. Later evidence suggests that this is likely to be a conservative estimate.



Raising the young To feed both themselves and their young, shearwaters fly out to find suitable fishing grounds at sea. It has been calculated that adult shearwaters from the

The shearwater's underground nest

Often nests are made in rabbit burrows. The shearwaters evict the hapless rabbits, using their sharp claws and hooked beaks to secure vacant possession of a suitable-sized burrow.



Above: Shearwater pairs that do not take over rabbit burrows dig new ones for themselves in the soft, peaty soil of the cliff top. A typical burrow consists of an entrance tunnel and a slightly larger nest chamber, which is lined with fronds of bracken and pieces of grass.

Right: A shearwater nesting site, as it appears after many years of burrowing.

Welsh colonies travel as far afield as the Bay of Biscay to find food, returning within one to two days. Most of their food is small in size and taken from the zooplankton, and includes many species of fishes and the young stages of crustaceans and molluscs. The shearwaters fish by diving from the surface and swimming powerfully under water.

The young shearwater, on emerging from the egg, soon develops large quantities of fluffy grey down, and resembles a ball of fluff from which eyes, beak and feet appear incongruously. The parents feed it with a smelly, oily mixture of fish and plankton which is regurgitated from the crop, where it is stored on the long fishing journeys. This mixture is highly nutritious, and the chick grows quickly, becoming very fat. The layer of fat it acquires provides a useful reserve food store for the chick. This is vitally needed, for the parental feeding visits are made after dark, and may not occur every night.

Expert navigators A shearwater has remarkable powers of navigation. Around its 70th or 80th night, the chick fledges: it spends a short time performing vigorous wing-flapping exercises before taking off on its maiden flight. On this journey, without the guidance of an accompanying parent, the young shearwater heads for wintering grounds out at sea off the coast of Brazil. Some birds, however, certainly do go astray. They are liable to be diverted by the violent winds of the south Atlantic. There is one record of a ringed shearwater washed up dead on the coast of southern Australia.

Manx shearwaters have good homing powers, too. Some years ago, an adult female was removed from the egg she was incubating in a burrow on Skokholm, Pembrokeshire, and flown (by aircraft) to Boston in the United States. There, she was released from a tall building. She had returned to her burrow before the letter announcing her release had reached the island!

Above: A Manx shearwater chick in the burrow. Its parents feed it on fishes and marine plankton.

Right: The single egg is usually laid in late May or June. It is oval in shape and a non-reflective white, although its colour soon changes, for it becomes stained by the peaty soil. The parents share the task of incubating, sitting in spells of three to five days and changing over at night. Change-overs may be delayed if bright moonlight illuminates the area and makes the returning bird easily visible to predators such as gulls. Bad weather may also delay the return of the partner bird. Incubation lasts just over 50 days.

Left: A young shearwater, about to reach the age when it will depart on its migratory flight. Fledging usually takes between 70 and 80 days; for about the last 10 days the chick is not visited or fed by its parents. By the time they cease feeding the chick, it has grown far too heavy to fly, and its excess weight is used to complete feather and muscle development as well as for day-to-day sustenance. Eventually, it will struggle out of its burrow and indulge in vigorous wing-flapping exercises to bring its muscles into tone for its maiden flight.

PLANTS IN NEED OF PROTECTION

Above: A wild gladiolus (*Gladiolus illyricus*) in its last remaining site in Britain, the New Forest. Fortunately, protection measures have helped to maintain its numbers here.

Below: One of our rarest species, wild cotoneaster (*C. integerrimus*), of which only five plants are known, all on one headland.

Some of our plants are so rare that they are protected by law, yet man's increasing pressure on the environment still puts their future in doubt.

The passing of the 1981 Wildlife and Countryside Act gave full legal protection to 62 rare species of wild plant, so that it is now illegal intentionally to pick, uproot, destroy or sell any of them, and to collect or sell their seeds. This number is a great increase on the 21 species protected by the previous Act of 1975, a fact that reflects both a growing concern about our disappearing flora and also the increased pressures on the listed plants.

That these plants are rare is due to a few causes common to most of them. The great majority of the protected plants are on the extreme edge of their range in this country; they are much more common on the Continent but have been prevented from becoming more widely established here partly because of the isolating effects of the Channel and partly because of the colder climate. Some species have declined rapidly in recent years due to changes in agricultural practices while others were never very common in this country. But some of our most spectacular losses have occurred when large areas of habitat have been allowed to vanish–in order to protect the plant it is essential to protect the habitat.

Vanishing heathlands Heathland is one of the most unstable of habitats. The soil, which is nearly always poor in nutrients, is liable to be washed away and the vegetation is prone to often highly destructive fires (witness the late summer of 1976). It is also a habitat that man can use–it can be built upon or converted into pasture land. So it comes as no surprise to learn that large areas of heath are under threat and that the habitat generally is in decline.

The New Forest now supports one of the largest areas of heathland in Britain, and it is here that a gem of a plant, the wild gladiolus, can be found. It resembles a small neat garden gladiolus, with superb rose-red flowers. It has suffered for its handsomeness in being continually picked or uprooted. Two sites–one in Dorset, the other on the Isle of Wight–have been lost, and it now survives only in the New Forest.

East Anglian Breckland A highly specialised form of heathland characteristic of East Anglia, Breckland consists of a deep, sandy soil overlying chalk. In such dry conditions the surface vegetation is often sparse and easily damaged, opening the way to erosion by the prevailing easterly winds. Like heathland, it is also liable to be built upon or converted into farmland.

In this apparently unfriendly terrain are found two protected plants, field wormwood and small Alison. The former is a perennial growing to a height of 60cm (2ft) with small yellowish flower-heads. Despite its height it is

Left: Bedstraw broomrape (*Orobanche caryophyllacea*), a distinctive plant with stout, pale stems, is restricted to sand dunes in east Kent, where it is fortunate enough to be protected by a golf course that maintains plenty of 'rough', thus allowing such rarities to survive.

Right: One of the rarest and most attractive plants of chalkland woods is the military orchid (*Orchis militaris*), a species believed to be extinct in this country until it was rediscovered in 1947. Today it exists at two sites, one in the Chilterns and the other in East Anglia. In both places it is well protected from damage, both accidental and deliberate, and also against thieves–sad to say, for the military orchid, with its spike of small soldier-like flowers, is much in demand on the black market.

an inconspicuous plant, blending easily into the surrounding grasses among which it grows. Such invisibility can work against it–a plant that cannot be seen easily may be difficult to protect.

Small Alison, on the other hand, is rarely more than 15cm (6in) tall in Breckland and usually much shorter, with numerous tiny creamy-white flowers. It was introduced to Britain a long time ago from southern Europe, and in Breckland it finds soils that closely resemble the dry sandy conditions of its native regions.

Ponds under threat The village pond is an English institution. Unfortunately, this does not extend to ponds in open country, and all too often these are left to silt up or regarded as a nuisance and drained. With the loss of any wet area (and more wetland habitats than any other are lost in this country), a unique reservoir of plant and animal life vanishes.

In Gloucestershire there is one of the smallest nature reserves in Britain. It is simply a pond enclosed by a fence and contains most of Britain's stock of a small yellow buttercup, adder's-tongue spearwort. Because it is an annual, the conditions for germinating must be right every year and any change in the pond, such as silting up or being drained, endangers the plant.

Something along these lines may already have happened to brown galingale, a plant related to the sedges. It is now present in just three localities in Somerset, Hampshire and Middlesex, and of these three only one population is of a viable size. Without its own special reserve, rather like that of the adder's-tongue spearwort, this plant's extinction is probably just a matter of time.

Below: The modern practice of cleaning crop seeds to remove potential weeds has caused the decline of many cornfield weeds, including the field cow-wheat (*Melampyrum arvense*). This species used to be so common that, in some areas, the local flour had a distinctive taste because of the presence of its seeds.

Seaside rarities Quite a few plants seem to like a bracing sea breeze. One such is bedstraw broomrape, a parasite living entirely at the expense of lady's bedstraw. Unfortunately, it lives in an unstable habitat–sand dunes–always liable to erosion by the wind and under great pressure from holiday-makers and tourists.

Other rare plants are more typical of the beach–also a precarious area often damaged beyond redemption by the combined forces of the sea and the holiday-maker. A rare plant of shingle beaches, found over a small stretch of the south coast, is Childling pink, a small annual plant with flowers resembling those of a pink.

One particular limestone headland is the

last refuge for the wild cotoneaster, a small, low-growing bush which was once more common but has been greatly reduced by grazing from goats and sheep, and also by over-collecting–an unpardonable sin.

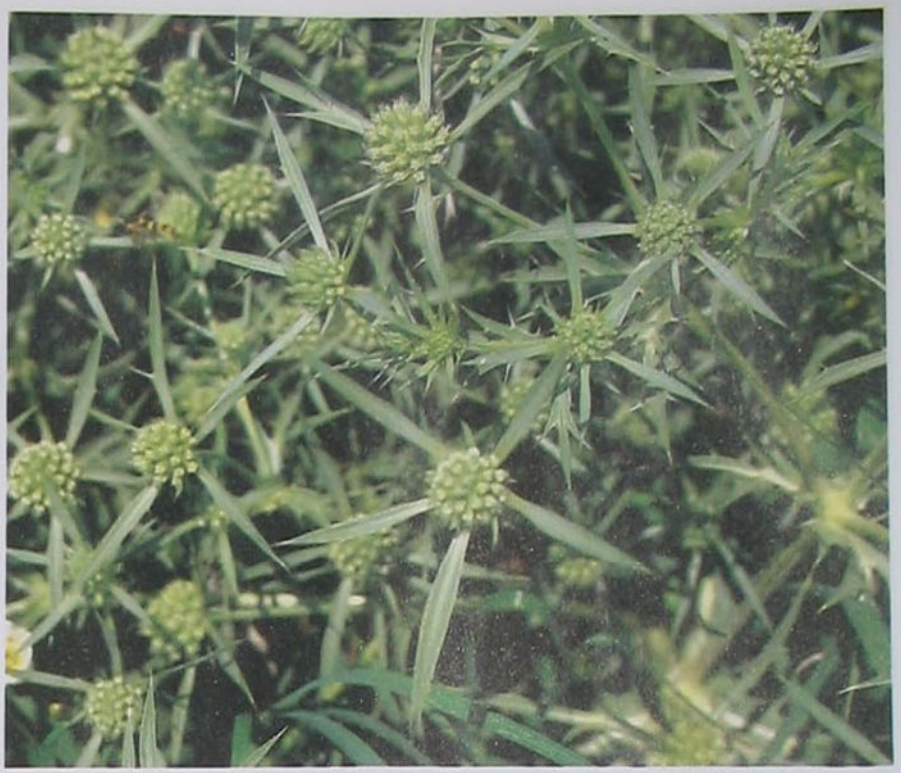
Calcareous woodland This splendid habitat is always full of interesting plants and, like all woodland areas, easily endangered by wrong-headed management schemes that replace the broad-leaved trees with conifers or clear them for timber. Chalk or limestone woodland shelters many protected plants, among which is the handsome alpine woundwort, with its large red and yellow flowers. It is now restricted to one small area of the Cotswolds.

Hedgerows and roadsides Hedgerows are disappearing at an alarming rate in Britain as farmers increase the size of their fields. With them goes a unique habitat for many plants. Hedgebanks, too, have suffered as Local Authorities endeavour to tidy them up with weedkillers, mowers and the planting of alien species. One hedgebank plant that has become very much rarer is downy woundwort, which is about the same shape and size as the alpine woundwort but covered all over in long white hairs and bearing pink flowers. Never a very common species, the downy woundwort is now found only in a small area of Oxfordshire.

A disappearing plant of hedgerows and field edges is the field cow-wheat, a handsome plant growing to 60cm (2ft) tall with showy pink and yellow flowers surrounded by pink bracts. It is a partial parasite, battening on to grass roots to supplement its supply of water and mineral salts. Once a very common weed of cornfields, it has suffered from the modern practice of 'cleaning' wheat seeds and the advent of selective weedkillers.

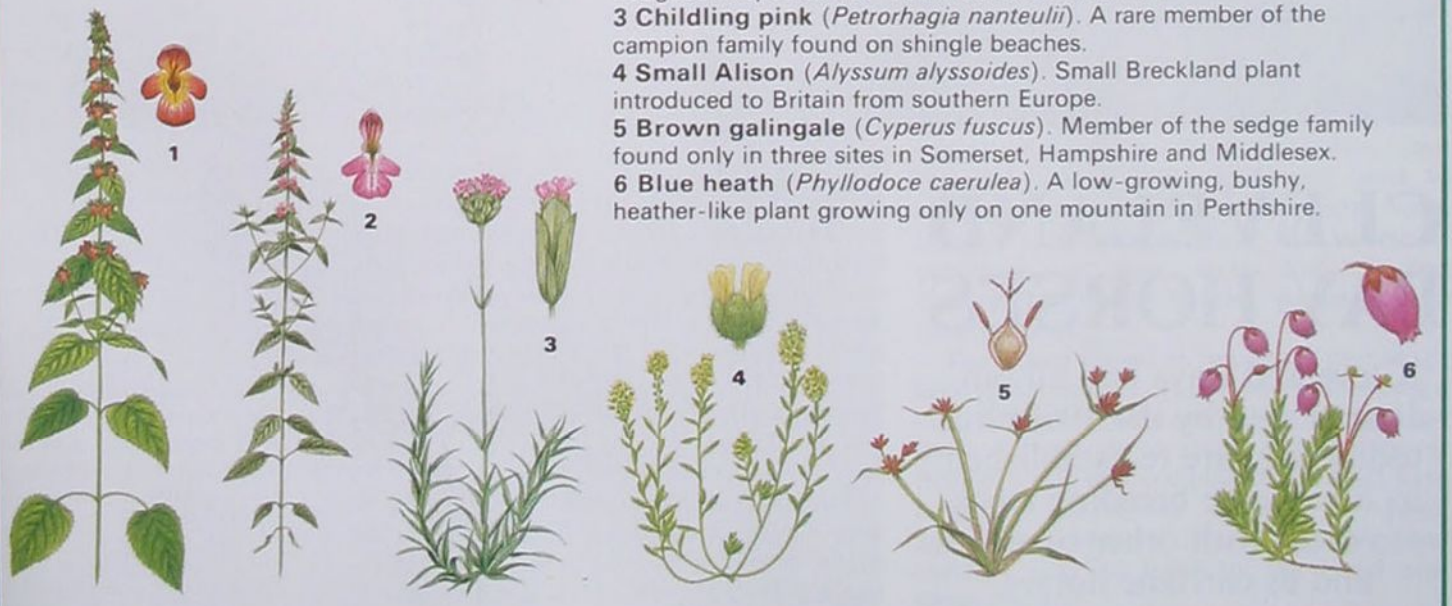
Mountain relicts Mountains are reserves for plants from another age–in Britain they bear the same species as flat lowlands did during the last Ice Age. One completely unexpected left-over was a small, white-flowered shrub called diapensia, discovered on a mountain in the west of Scotland. It is an Arctic shrub found all around the North Pole, but nowhere else in Scotland. Another relict plant is blue heath, a low bushy shrub resembling heather.

As a habitat, mountains are less likely to be damaged and only man threatens their protected plants. Other habitats, however, are more easily destroyed, both by natural causes and by man, and must be carefully conserved if their rare species are to survive.



Above: A good example of a plant isolated by the English Channel is the field eryngo (*Eryngium campestre*). Very common throughout much of France, Spain and Portugal, in this country it has always been uncommon and is now in decline. Its main site is a limestone cliff near Plymouth. With its compact flower-heads and spiny, yellowish-green foliage it looks like a thistle, though it is actually a member of the carrot family.

British rarities



1 Alpine woundwort (*Stachys alpina*). Perennial member of the mint family found only in the Cotswolds.
2 Downy woundwort (*Stachys germanica*). A declining hedgebank species now confined to Oxfordshire.
3 Childling pink (*Petrorhagia nanteulii*). A rare member of the campion family found on shingle beaches.
4 Small Alison (*Alyssum alyssoides*). Small Breckland plant introduced to Britain from southern Europe.
5 Brown galingale (*Cyperus fuscus*). Member of the sedge family found only in three sites in Somerset, Hampshire and Middlesex.
6 Blue heath (*Phyllodoce caerulea*). A low-growing, bushy, heather-like plant growing only on one mountain in Perthshire.

CLEVELAND BAY HORSES

Cleveland Bays had all but disappeared by the 1960s but today they are re-established as a valuable breeding stock to cross with other breeds, and as carriage horses.

The Cleveland Bay is one of the most ancient of British horses, having been known in a form not so very different from the present at least since medieval times. The breed takes its name from Cleveland, the beautiful area of hills and dales in North Yorkshire, bounded approximately by Stokesley, Helmsley, Guisborough, Whitby, Pickering and Scarborough. The breed was founded on the active, strong, clean-legged horses that had developed there over centuries.

These horses were predominantly bay in colour, and the official standard for the modern breed is bay with black 'points'–legs, mane and tail. Legs which are bay or red below the knee are accepted, but are not really

Above: Prince Philip often uses Clevelands or part-Clevelands from the Royal Mews in his highly successful teams of four when he represents Great Britain in the arduous sport of Combined Driving. Although Clevelands are now regarded primarily as a breed to cross with others, they are still used as carriage horses, notably in the Royal Mews.

true to type. Grey hairs in mane and tail are permitted in certain strains; white is unacceptable, except as a small star on the forehead.

Today's Cleveland is a fine, strong, upstanding horse of at least 16-16.2 hands (162-168cm/64-66in) in height, with a minimum of 23cm (9in) of good, flat bone measured below the knee of the foreleg at the narrowest point. The head tends to be large–larger than that of a Thoroughbred of the same size. The feet must be hard, broad, deep and 'blue' (blue-black) in colour.

The past The early horses found in the Cleveland area were smaller than the modern breed. Then 15 hands (152cm/60in) was large. From the outset they were used as utility animals, working on farms, as pack animals and for riding. They were in great demand for their fast, active walk, their great endurance and their ability to exist on minimum rations.

With the advent of coaches in Elizabethan times the role of the Bays changed. Their strength made them ideally suited to pulling the great lumbering vehicles along muddy roads. Much later, in the 18th century, Thoroughbred blood was introduced to give more speed, and there were then two types of animal within the breed–the older type of heavier, slower animal used in agriculture, and the rather lighter, faster horses for harness work.

Two Thoroughbred stallions, Manica and Jalap, are regarded as being the most influential in the breeding of the faster Clevelands, from which today's horses are directly descended. All modern Thoroughbreds trace back to a very small number of Arab and Oriental stallions which were imported at the end of the 17th and 18th centuries. Thoroughbred is believed to be the only outside blood in Clevelands and breeders are proud that there is no 'black' (cart-horse) blood in their horses.

Above: A cleveland Bay stallion and (below) a mare and her foal. Since the last century Cleveland Bays have been used to upgrade other breeds to obtain good quality hunters as well as competition horses. They are famed for their strength: records tell of one horse which was ridden 40 miles to Newcastle in the morning and 40 miles home in the evening, swimming the River Tees twice on the journey.

A standard of breed perfection was laid down for the Cleveland Bay in 1827, at which time the height was 15.3-16 hands. Soon, however, with the introduction of lighter, more elegant vehicles such as barouches, there was a demand for high-quality pairs of matched carriage horses standing anything up to 17 hands. This was achieved by crossing Cleveland Bays with big Thoroughbreds to produce an animal that came to be known as the Yorkshire Coach Horse. Throughout the 19th century this breed was seen in the carriages of the nobility.

Today's Cleveland Bays With the coming of mechanisation on farms and in transport, the Yorkshire Coach Horse vanished from the scene and the Cleveland Bay all but followed suit. By 1962 there were just four mature stallions remaining in the British Isles–although a number of the breed had been exported to various other countries. Fortunately a few enthusiastic breeders remained loyal to the breed and began to exploit yet another of its great qualities. Since the last century Bays had been used to upgrade other breeds, giving them bone, strength and substance, and their worth as producers of top class hunters and competition horses became paramount in their survival.

The Queen played an important part in the survival and revival of Clevelands. She saved a colt, Mulgrave Supreme, from export and made it available to stand as a stallion in Britain. From him and other Clevelands have come an impressive number of good, substantial hunters, show jumpers and eventers, and the future of the breed now seems assured.

CAPSID BUGS AND LACE-BUGS

As members of the bug order (Hemiptera), capsid bugs and lace-bugs possess sucking beaks which enable them to cause considerable damage to plants, a characteristic which has earned them a bad reputation among gardeners and farmers.

Capsid bugs (Miridae) and lace-bugs (Tingidae) are two families of bugs which superficially resemble small beetles, although under closer examination you can see their two distinguishing features: the beak for sucking, and the two small triangles (seen from above) formed by the folded wings and part of the thorax.

More than 200 capsid bug species are found in Britain, several of them occurring in summer on almost any tree, bush or patch of vegetation. They have usually been considered vegetarian feeders but it is now known that a large number of species are partially predatory, feeding on the eggs and young of other insects.

Pest of strawberries One of the most abundant capsid bugs is the common green capsid, found all over the British Isles. About 5-6mm long, this bug is light green, resembling the foliage on which its lives.

The female lays her eggs singly in September in slits in the twigs of woody plants (apple, plum and lime trees, hawthorn and currant bushes), using either existing crevices or making small incisions with her serrated ovipositor. She lays up to 50 eggs.

The eggs overwinter and hatch the following spring from mid-April to mid-May–when the apple trees are in blossom. The young nymphs feed at first on the leaves at the tips of young shoots, and on the rosette leaves of blossom trusses, later attacking the young shoots and fruitlets. The older nymphs and adults which appear in June, however, leave their woody plant hosts and attack herbaceous plants–they particularly favour raspberries and strawberries. These adults lay eggs in the stems of herbaceous plants, giving rise to a second generation, the adults of which appear from mid-August onwards. They mate and then return to the woody hosts where the females lay their overwintering eggs.

Not surprisingly, the common green capsid is frequently regarded as a pest. The young nymphs of the first generation damage the fruit by puncturing its skin and leaving brown spots when feeding, while the second generation of nymphs cause malformed strawberries.

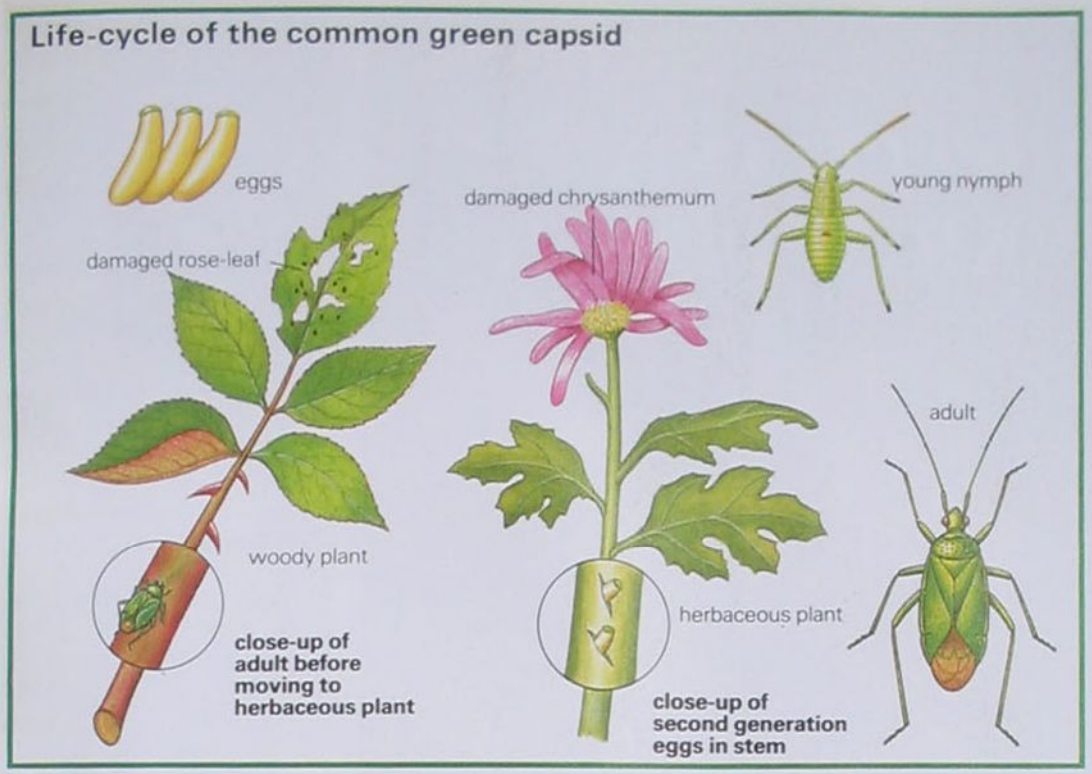
Apple capsid A species similar to the common green capsid is the apple capsid. Originally found on willow and bog myrtle (where it is still seen) it has, since 1914, moved on to apple trees and currant and gooseberry bushes, becoming a major pest until DDT sprays controlled it so effectively that it now seldom occurs. Unlike the common green capsid it has only one generation a year; this stays on the woody host and does not migrate.

The eggs are laid in bark crevices in June and July; here they spend the rest of the summer and winter. They hatch from April to May and the adults appear in June, living for four to six weeks.

Potato virus carrier The European tarnished plant bug is another extremely common species, found throughout the British Isles. It is about 5mm long, and is a shining greyish-green colour with dark spots and markings. This species feeds on a wide variety of plants, but especially on the goose-foot family, and also on nettles, docks and clover. They

Above: The capsid bug *Miris striatus* is omnivorous, feeding on aphids, insect eggs and larvae, as well as the young parts of trees.

Below: The common green capsid (*Lygocoris pabulinus*).



Left: The eggs are laid in slits in woody twigs (here a rose) to overwinter. In spring these hatch into nymphs which feed on the young leaves; on becoming adult they move to herbaceous plants, where more eggs are laid, making a second generation.

Apple capsid bug
(Plesiocoris rugicollis)

European tarnished plant bug *(Lygus rugulipennis)*

Rhododendron lace-bug
(Stephanitis rhododendri)

Thistle lace-bug
(Tingis ampliata)

Below: *Pantilius tunicatus* is green at first when adult, but turns reddish, then black.

sometimes transfer from these hosts to potatoes, lucerne, chrysanthemums and raspberries, where they may cause extensive white spotting all over the plant as their saliva kills the tissue. It is thought that they also act as carriers for potato virus.

The European tarnished plant bug overwinters as an adult in dead leaves and other litter, coming out in March or April to mate. The female lays her eggs in the unopened flower buds and stems of the host plants, where they hatch into green nymphs which become adult towards the end of July. These adults, in turn, lay eggs to produce the autumn generation. The adults are particularly long-lived, so much so that overwintered females have been found still living in August with the autumn generation–their grandchildren.

Larger capsids A longer capsid bug at 8-10mm, *Pantilius tunicatus* is greenish in colour when young, but becomes reddish and black later. It is found on hazel, alder and birch in late September and October, when the female lays eggs at the bud bases or in leaf scars. These do not hatch until the following August or September.

Miris striatus is another relatively large species, 9-11mm long and strikingly coloured in yellow and black with an orange spot next to the wing membranes. It is found on many deciduous trees, but especially oak and hawthorn in late May and June. The eggs overwinter and hatch in April and May, producing reddish brown nymphs with yellow markings. Both nymphs and adults feed, to some extent, on the young parts of the host tree, but their main diet includes aphids, scale insects, bug eggs and the larvae of small moths.

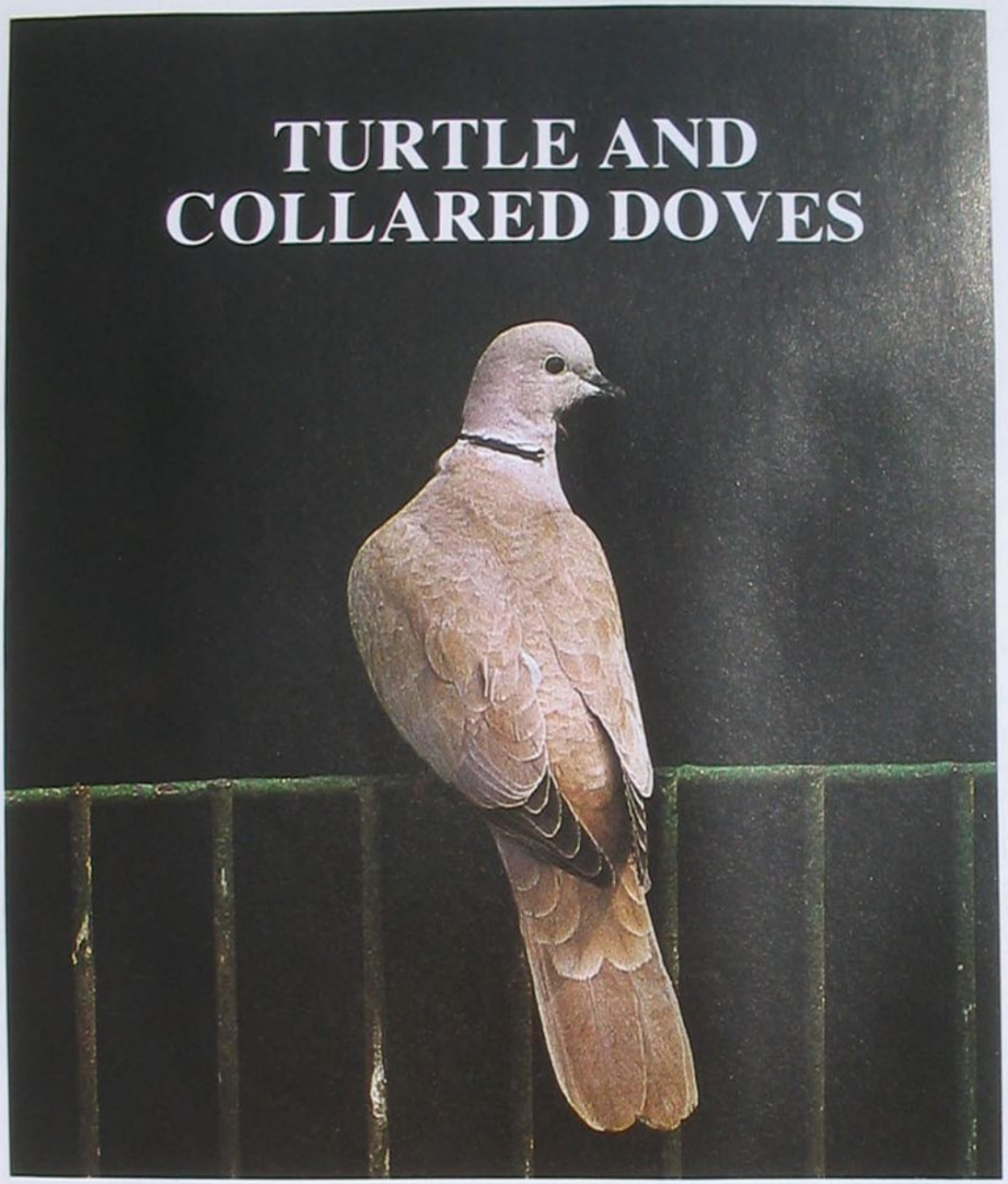
Pretty lace-bugs The intricate lace-like network of tiny ridges on the upper surface of the thorax and forewings has given lace-bugs their name.

Out of the 23 British species, the easiest to find is the thistle lace-bug. The adults overwinter in moss and leaf litter near creeping thistle, their host plant. In May they colonize these thistles, aggregating on only certain plants, where their numbers stabilise at approximately nine per plant. They mate in June. The eggs are embedded in the thistle tissue and the hatching nymphs migrate to vegetative (not flower) buds.

The rhododendron lace-bug is a delicate, particularly attractive insect, about the same size as the thistle lace-bug but with a coarser 'lace-work' pattern. It probably came from North America, but is now well established in England, south Wales and southern Scotland.

The female lays her eggs in rows embedded in the underside of leaves, where they overwinter. At first the nymphs are pale and green and remain in small groups which reassemble if disturbed, but later on they disperse and become browner.

TURTLE AND COLLARED DOVES



Left: A collard dove on a garden fence. The tail is long and, when viewed from above, is sandy brown in colour, with a barely discernible white margin; viewed from below, about half its length is white.

Turtle dove (*Streptopelia turtur*). Summer visitor to farmland. Sexes are alike. Length 28cm (11in).

Collared dove (*S. decaocto*). Resident in cereal growing areas; sexes alike; 32cm (12½in).

Above: The turtle dove breeds mainly in the south, south-east and Midlands of England, roughly speaking east of a line from Exeter to Liverpool and across to Tees-side. The collared dove on the other hand has a wider distribution, having established populations in most cereal growing areas. The lower map shows how the collared dove spread throughout most of Britain and Ireland during the course of 7 years: an unusually rapid rate.

The turtle dove, an attractive summer visitor, has been commonly known in Britain for centuries. Its larger relative, the collared dove, is by comparison an upstart. Since 1955 this bird has invaded Britain and Ireland on a grand scale, establishing a resident population of over 100,000 pairs.

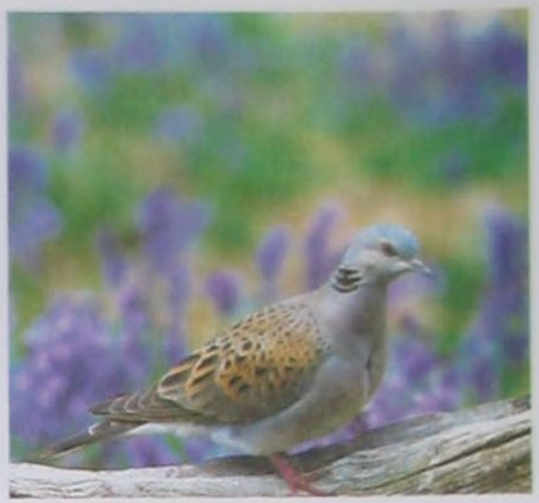
The turtle dove is a small, fast-flying pigeon which visits our woods and farmland in summer, having spent the winter in Africa. It is the smallest of the British and Irish pigeons, hardly bigger than a mistle thrush. (The term 'pigeon' and 'dove' are generally used rather loosely and can be interchangeable; often, however, 'pigeon' is used for the larger species, and 'dove' for the smaller.)

The head and neck are grey (the proverbial dove grey) while the mantle, back and rump are brown. The wing coverts, best seen on the closed wing of a perched bird, immediately distinguish the turtle dove from all other pigeons. They are a rufous bronze, and each feather has a black centre, producing a strikingly beautiful effect. This is enhanced by the underparts, which are fawn with a rich pink shading deepening on the breast. The belly is pure fawn.

The tail, long and tapered at its tip, is dark brown with a white border. This border, when seen from above, is narrow, but on the underside it forms a conspicuous margin of roughly even width right round the tail, which is often held fanned in flight.

On each side of the neck is a white, roughly oval patch, crossed by three or four black lines. The two sexes are very similar in plumage, but young birds are generally duller and browner, and lack this neck patch.

Purring song Several of the earliest



references to bird migration are in the Bible, and one of these, in the Song of Solomon, refers to the turtle dove's song as one of spring's most welcome sounds. The 'voice of the turtle' is a long, peacefully drowsy purring song. In suitable areas of scrubby woodland, turtle doves can occur in large numbers, and on hot summer days they fill the woodland air with their song. The sound is characteristically hard to locate, so that it becomes difficult to pinpoint any individual.

Farmland birds Turtle doves are primarily birds of the arable farmland of southern and eastern England. They are not as closely associated with large areas of thick woodland as woodpigeons are, for they need open rural areas in which to feed. Unlike most related pigeons, they seem unable to live in towns or even villages. They eat a wide variety of seeds, but fumitory is a special favourite, and is ripe all the time turtle doves are in this country. Indeed, the maps of the breeding distribution of the turtle dove and of the occurrence of fumitory show a remarkable similarity.

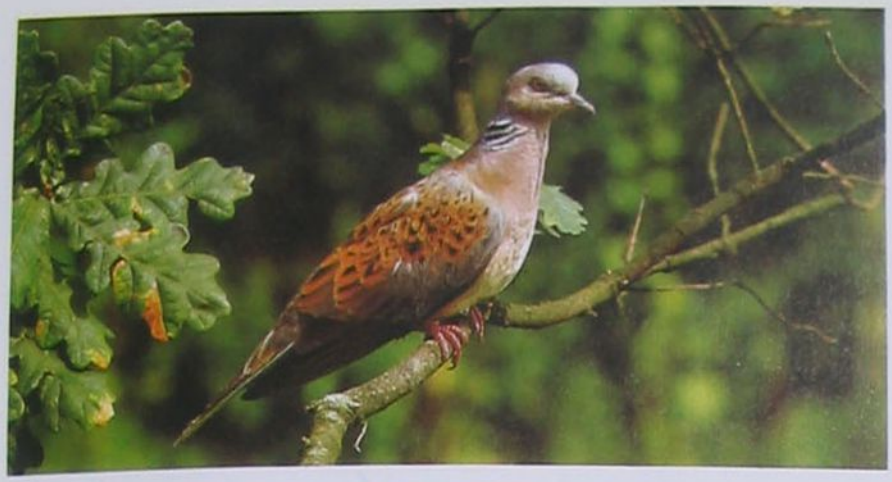
Small flocks of turtle doves are often noticed when disturbed from the gravelly surface of quiet country lanes: they enjoy sunbathing on the warm tarmac, but also pick up sharp pieces of grit and swallow them. Since birds have no teeth, those (like the turtle dove) that live on tough, dry seeds use this grit in their gizzards to help grind up their food for easier digestion.

Turtle dove migration Although they are among the latest migrants to arrive, and breeding is usually not under way until mid- or late May, most turtle dove pairs attempt to raise at least two broods, and sometimes three, in the course of their stay in Britain or

Above: Young turtle doves exercise their wings. They look ugly in comparison with the adults, and part of their ugliness is derived from their long beaks. These are adapted to drink 'pigeon's milk'–a milky-coloured secretion–from the adult's crop. Although not the same as the milk of mammals, the fluid is highly nutritious and the young grow fast.

Above right: The graceful adult turtle dove.

Round-up of doves and pigeons



Above: A turtle dove, showing its fine mixture of plumage colours.

Left: Some collared dove nests are on open ledges on buildings–some are even sited on the tops of telegraph poles or builders' cranes. There is at least one nest on record that is made entirely of pieces of wire. Collared doves are evidently more tolerant of man-made structures and materials than turtle doves. Collared doves sometimes breed in winter, but usually do so between March and October. It is thought that most pairs attempt to raise at least three broods during this long season.

Below: A collared dove sits on its nest. The collared dove's song is less musical than that of the turtle dove–a repeated 'cooh-*cooh*-cooh', with heavy emphasis on the middle syllable.

Ireland. At the end of August, and through September, flocks of turtle doves wing their way south to cross the Mediterranean. The birds have to brave the natural hazards of long-distance migration, and must also run the lethal gauntlet of hunters in southern Europe, where the turtle dove is regarded as a great delicacy.

Collared doves These are appreciably larger than turtle doves; in flight, they are clearly heavier-bodied and more falcon-like. The body plumage of both sexes is a drab, almost uniform pale sandy grey-brown. The head and underparts are sometimes faintly tinged with pink. The wing coverts, too, are sandy coloured, contrasting with darker brown primary feathers. The most conspicuous feature of the body plumage is the narrow black half-collar round the back of the base of the neck, edged narrowly with white.

An ecological niche During the middle 1950s, all birdwatchers wondered if our native bird life might be affected by the arrival of the collared dove, an unexpected newcomer to Britain and Ireland. Would the turtle dove, for example, be displaced? In the event it was not, for when the collared doves arrived they occupied their own ecological niche–an opportunity for survival that had hitherto been unexploited by any native British bird. This opportunity can be summed up in a single word: grain. Where plentiful amounts of grain are spilt on the ground–mainly in the vicinity of grain stores, which are common in arable farming areas–collared doves feed easily. The birds also take grain as it ripens in the fields.

While other birds–for example sparrows–also live on these grain supplies, the collared dove demonstrated that there was room for a larger, tree-nesting species of resident grain-eating bird, and wasted no time in filling the vacancy.

Invasion force Collared doves always seem to be associated with man, especially in areas where grain is readily available. Most grain stores now have a resident population, as do most poultry farms. Many of the early records of collared doves in Britain were in the vicinity of domestic chickens, whose food supply the doves shared. At this early stage no-one realised that just a decade later collared dove numbers would have exploded to the extent that the birds would be classified as pests in some areas.

The rise of the collared dove is thus one of the most fascinating bird success stories. Originally the species was widespread, and often very numerous, in Asia and Africa. The cause of their widespread expansion is clearly a change from a sedentary pattern of life to a 'nomadic' life of travelling and pioneering new habitats. How such a change can happen is, however, not entirely understood: it seems likely that it is associated with a genetic change (a mutation), for once it had occurred, it was evidently transferred to all following generations of collared doves.

The westward spread from Asia began in the 1930s, and by the mid-1950s the birds had reached Britain: a pair bred in Norfolk in 1955. By 1964 there was an estimated breeding population of 300 pairs, and today it seems reasonable to guess that the collared dove population is roughly on a par with that of the turtle dove–somewhere in excess of 100,000 pairs in Britain and Ireland. It is now probably stable at this level.

EXOTIC HICKORIES AND WINGNUTS

Closely related to the walnut, hickories and wingnuts are at their most ornamental in the autumn when their golden-yellow foliage (as on the shagbark hickory shown below) is complemented by decorative fruits.

In Britain the most familiar member of the walnut family (Juglandaceae) is the walnut itself, a tree that has been cultivated here since at least the 15th century for its nuts and its highly prized wood. World wide, however, the family is represented by six other genera. Three of these are confined to tropical parts of Central America and south-east Asia, and are not hardy enough to grow in our temperate climate. The remaining three genera are represented by temperate species, some of which can be seen in our parks and public gardens.

Three hardy genera These hardy members of the family can be divided into two groups. One consists of the hickories (*Carya* species),

most of which (approximately 20 species) come from eastern North America. The fruits of a hickory are similar to walnuts and botanists often separate out these two groups from the other genera and place them in their own sub-family.

By contrast, species in the other two genera (*Pterocarya* and *Platycarya*) bear a quite different form of fruit, as suggested by their common name, wingnuts. These fruits consist of long pendulous chains of winged nuts. Both genera are native to Asia and thrive in regions where the climate is similar to that found in this country.

Species in Britain Of the two groups–hickories and wingnuts–the wingnuts are more commonly seen in Britain, and of these the Caucasian wingnut (*Pterocarya fraxinifolia*) is the most widely grown. Native, as its name suggests, to the Caucasus Mountains of the Soviet Union and to Iran, this species represents the western limit of the genus. The other seven species come from China and Japan. Of these, the Chinese wingnut (*P. stenoptera*) is the most widely planted. The other genus of wingnuts, *Platycarya*, is said to be monotypic since it has only one species, *P. strobilacea*. Native to China, Japan and Korea, this graceful tree is rarely seen in this country outside botanic gardens and arboreta.

The hickories are a less familiar group in Britain, though with their richly textured leaves and their sculptured barks they deserve to be more widely planted. The most commonly planted member of this group is the bitternut hickory (*Carya cordiformis*). As its name suggests, its nuts are completely inedible. Possibly the most attractive species is the shagbark hickory (*C. ovata*). The only other species seen in Britain with any regularity is the mockernut hickory (*C. tomentosa*) with its characteristically enormous grey buds and sweetly smelling leaves. This tree derives its name from the fact that its fruits are often empty.

Above: Introduced from North America in 1629, the shagbark hickory can occasionally grow to a height of 20m (65ft) or more in Britain. In the United States and Canada hickories have great importance as a commercial crop, whether for timber or nuts. The wood is tough, yet elastic, and ideal for the manufacture of tool handles for use in forestry and agriculture. In Britain, hickories are only ever grown for their ornamental value, though in recent years the pecan–which is a hickory fruit–has become increasingly popular here.

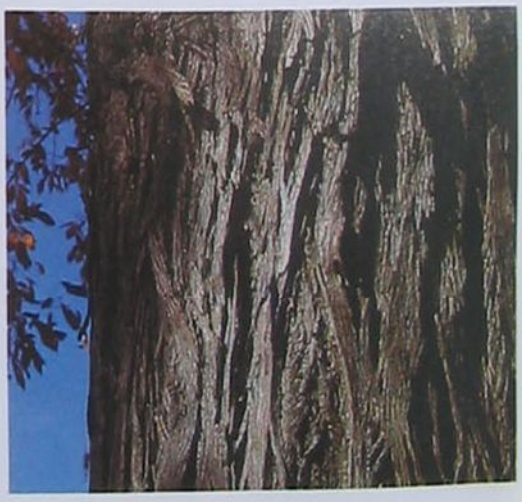
Compound leaves Both hickories and wingnuts have compound leaves similar to those of a walnut, in which the leaflets are arranged along each side of a central stalk–a structure known as pinnate.

Hickories can often be distinguished by the size of the leaflets and their arrangement on the leaves. The shagbark hickory, for instance, has only five leaflets to each leaf. Each leaflet is usually between 12cm (5in) and 18cm (7in) long, though they can reach a length of 30cm (12in). At the other end of the scale is the pecan hickory (*C. illinoensis*), from which we get the familiar nuts of the same name. Each leaf of this tree has between nine and seventeen leaflets which are pointed, toothed and curved like a scimitar.

Wingnuts usually have more leaflets to a leaf than do hickories, often as many as 25. Consequently the whole leaf can be much longer. The leaf of the Caucasian wingnut, for example, can be as long as 60cm (2ft).

Flowers and fruits In common with the walnut, both hickories and wingnuts bear their flowers in catkins. Among the wingnuts, the most spectacular flowers are borne by the so-called hybrid wingnut, which is a cross between the Caucasian and the Chinese species. Its female catkins can be as long as 45cm (18in), the male catkins being only a third as long as this. The hybrid wingnut is much hardier and more vigorous than either of its parents something that occurs frequently with hybrids.

The fruit of a wingnut consists of a small nut bearing two leafy wings and looking rather like a cross between an ash fruit and a



Right: The name 'shagbark' comes from the fact that, on mature trees, the bark splits into narrow strips that lift away from the trunk at each end–giving it a shaggy appearance. This curious feature probably confers the advantage of deterring squirrels from climbing the trunk and stealing the nuts.

Left: The rugged, fissured bark of a mature Caucasian wingnut. In its native countries the bark is used to make sandals and roof tiles, but the wood itself has little commercial value.

sycamore fruit.

In hickories, only the male flowers are borne in catkins. The female flowers are inconspicuous and borne in clusters at the tips of the new shoots. The fruit consists of an inner nut surrounded by a fleshy outer layer.

Perhaps the most foolproof way of distinguishing wingnuts (and walnuts) from hickories is to examine the pith inside young shoots. The pith of a hickory is solid whereas that of a wingnut or walnut consists of neat rows of plates that divide the interior of the shoot into chambers.

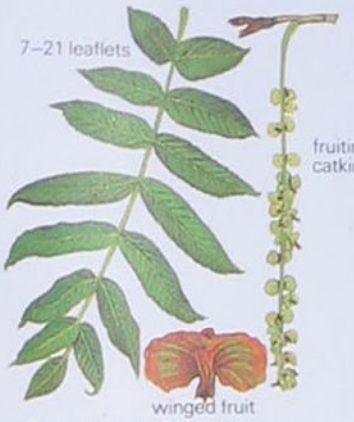
Tertiary relics In the past the British climate was very different from what it is now. Recent studies of ancient peat and sedimentary deposits have confirmed that the climate was once comparable to that of the humid tropics, similar to that found in present-day Malaysia, and the British flora was correspondingly much richer. During the Tertiary period before the last Ice Age the British land surface was dominated by trees now found in much more southerly latitudes, including hickories, wingnuts and walnuts. Towards the end of the Tertiary, Britain's climate deteriorated dramatically with the onset of the Ice Age and these species migrated, never to return.

Although our climate is much cooler than it was before the Ice Age, hickories and wingnuts grow well in the southern counties of Britain. A particularly interesting tree can be seen in the Cambridge Botanic Garden, where there is a thicket of Caucasian wingnut that has grown from a tree blown down in 1866. Ironically, beneath this thicket fossils of the same species can be found.

Below: A Caucasian wingnut with its long fruiting catkins. The leaves of this tree have an intoxicating effect, and some Caucasian fishermen utilize this to stupefy their prey before catching them.

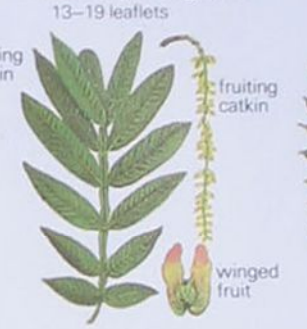
The walnut family

All three groups in this family have compound leaves with the leaflets arranged in the same pattern, known as pinnate. Generally, walnuts and wingnuts have more leaflets per leaf than hickories. All have male catkins but only wingnuts also have female catkins; the other two groups have inconspicuous female flowers. Wingnuts differ in their fruits as well, producing catkins of small, winged fruits rather than a single large nut.



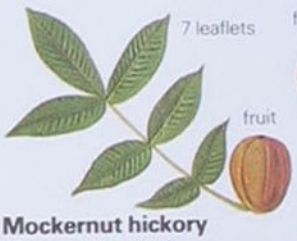
Caucasian wingnut
(Pterocarya fraxinifolia)

Bitternut hickory
(Carya cordiformis)



Chinese wingnut
(Pterocarya stenoptera)

Hybrid wingnut
(Pterocarya × rehderiana)

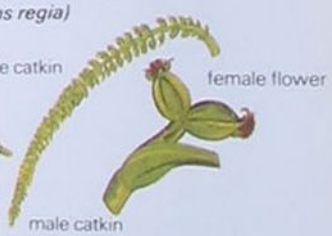


Mockernut hickory
(Carya tomentosa)

Shagbark hickory
(Carya ovata)

Common walnut
(Juglans regia)

Caucasian wingnut



Shagbark hickory

BARBEL: 'TORPEDOES' OF THE STREAM

A shoal of barbel is a thrilling sight. In spring you can see these dark, streamlined fishes in gravelly upland waters, where they spawn. In summer the shoals occur lower downstream especially where there are patches of gravel. They are fond of beds of water crowfoot and shady, overhanging river banks.

Above: Two barbel, showing their habitual manner of swimming close to the bottom. The growth of this fish is not rapid: a barbel that attains a weight of 3.5kg (8lb) at the age of 10 years is considered a fast grower. The largest barbel in the country are probably around 7.5kg (16-17lb), and the maximum age is around 16 years. In warmer waters, such as those of the Trent, the life-span is shorter.

The barbel is perhaps Britain's most striking member of the carp family. It is a long, torpedo-shaped fish, generally dark brown on the back and cream on the underside. The body attains its maximum girth at a point one-third of the way from the front. The pectoral fins are large, and with the streamlined body shape they help to press the fish against the bottom of the rivers in which they live. The most characteristic features, however, are the barbels: there are two pairs of these, attached to the upper lip. Another interesting feature is the serrated first spine in the dorsal fin. As in all cyprinids, throat or pharyngeal teeth are present; there are three rows of teeth on each side, with five teeth in the outside row, three in the middle and two in the inside row.

Barbel rivers The barbel is a bottom feeder, and its physical attributes are well adapted to this type of life. It is the classic fish of river zones with a fast current and clean water which is not too cold. This means that it occupies the middle zone, between the upland zone of the trout and grayling, and the sluggish downstream zone of the bream. Another classic habitat of the barbel, irrespective of river zones, is large weir pools, especially in rivers such as the Trent and Thames.

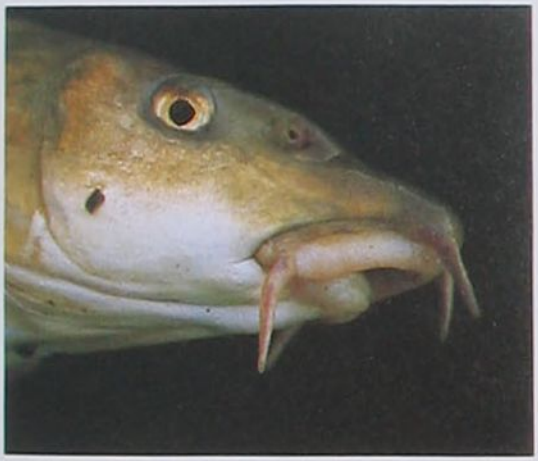
In general, barbel only tolerate fast flowing stretches of river and are noted as denizens of gravel stretches. Clay substrates are some-

times acceptable, especially where there are overhanging banks. Barbel live in relatively shallow water in summer, and retire to deeper and stiller water in winter, becoming virtually torpid.

The barbel originated in the rivers of central and eastern Europe. It spread to England in the period following the last Ice Age, some 7000 years BC. At that time, the eastern rivers of what is now England used to flow into the Rhine, which extended northwards into what is now the North Sea. This means that the barbel is native only to the old tributaries of the Rhine–the Thames, Great Ouse, Welland, Nene, Trent and all the tributaries of the Yorkshire Ouse.

Modern introductions Of all the angler-caught fish, barbel have had the most controversial distribution by man. In the 1880s a small consignment of barbel was introduced into the lower reaches of the Dorset Stour. Over the next few years the fish spread rapidly, invading the nearest large river, the Hampshire Avon.

In the 1950s a number of barbel were introduced into the River Severn and the Bristol Avon. The effect of this on the Severn



has been quite dramatic. The whole balance of the river's fauna swung in favour of the barbel, and huge numbers of young fish quickly spread up the river. They became so dominant in the late 1960s and early 1970s that it was thought they could damage the native fauna of the river permanently. Since this time, however, the fish seem to have 'struck a balance' with the native fauna, and do not dominate the river so extensively.

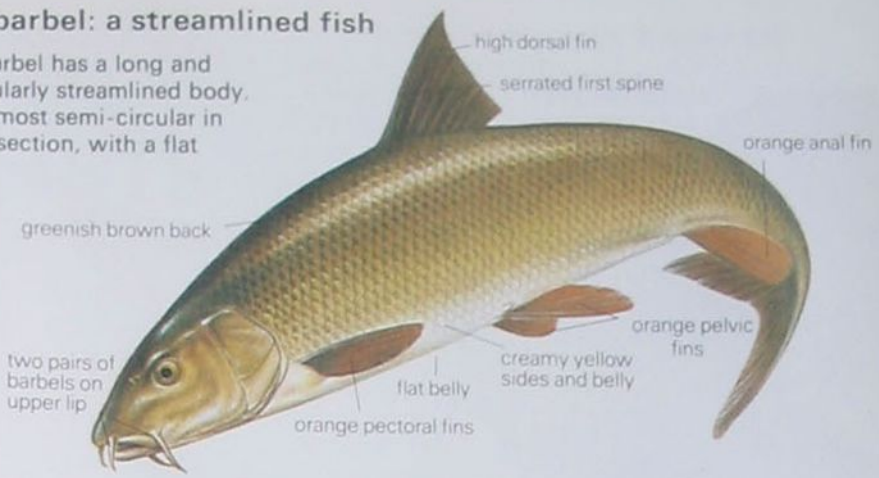
Breeding grounds The life cycle of the barbel starts in May, when the adults in a particular river migrate upstream to spawn. They may undertake a long migration to find a suitable substrate. The males are normally smaller than the females, and a number of them court one female. Only one fish is allowed the privilege of fertilising a batch of eggs; it does this at the moment when the female voids them into the fast flowing water over shallow gravel. Competition for spawning is therefore a strenuous activity. The males develop prominent whitish spawning tubercles, the vivid appearance of which helps to encourage the female to spawn.

The eggs are deep yellow in colour, and around 1.5mm in diameter. They are adhesive, but not so adhesive as roach or bream eggs. As they are voided, the current takes them into crevices in the gravel and between the stones. The protection provided by this substrate is important, as the incubation time is long–up to two weeks–and there is a constant danger that the eggs may be eaten by other members of the aquatic community during this period.

The alevins (larval fish), when they hatch, have a rather small yolk sac and must therefore feed avidly. At first they take very small food items, then they graduate to the adult diet of aquatic insect larvae and freshwater shrimps and snails.

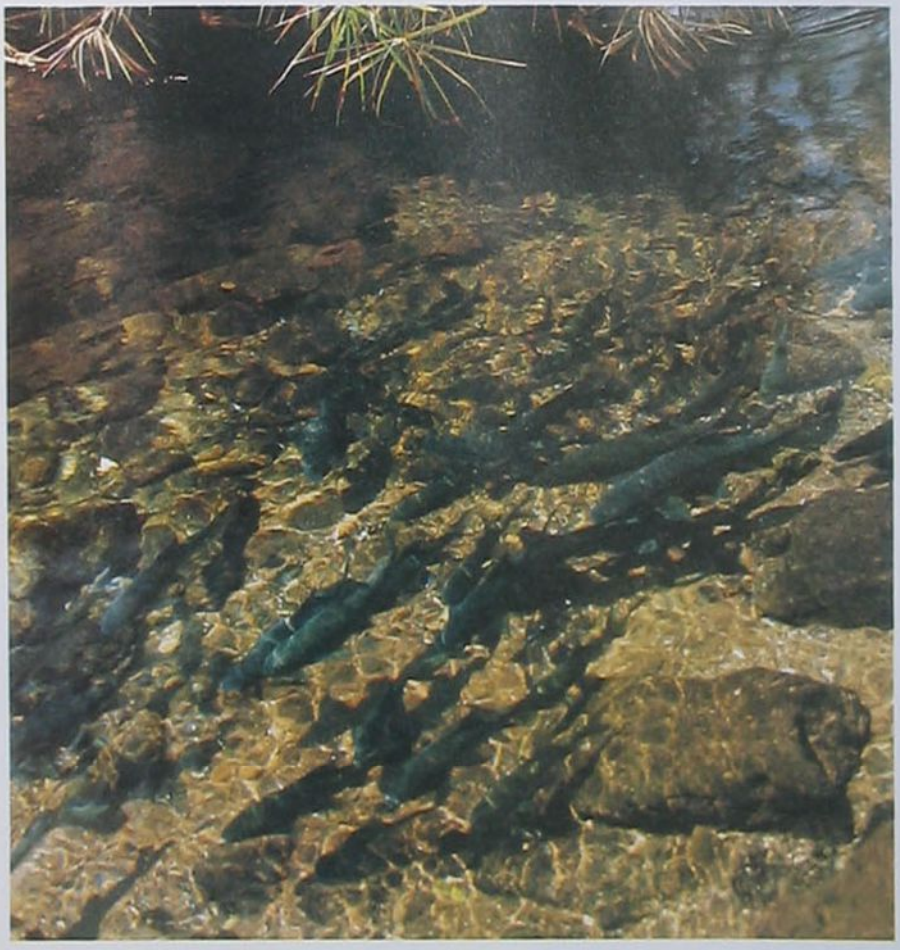
The barbel: a streamlined fish

The barbel has a long and particularly streamlined body. It is almost semi-circular in cross-section, with a flat belly.



Left: The head of a barbel, displaying the 'barbels' that give the fish its name. They are attached to the upper lip, one pair at the front and one at the back and help to locate the food organisms on which the fish preys. These are small aquatic animals–insect larvae and freshwater shrimps and molluscs.

Below: A shoal of barbel of various ages, seen in the typical summer habitat. Barbel are active in the half-light of dawn or dusk, as well as being voracious night feeders.



GOWER: CLIFFS, CAVES AND COASTS

Small though it is, the Gower Peninsula has great underlying geological diversity. The result of this on the land surface is impressive: so varied are the Gower soils and habitats that it is almost an entire ecological world in microcosm.

Mid-way along the south coast of Wales there is a relatively small promontory shaped roughly like a baby's bootee with the 'toe' pointing to the west. This is the Gower Peninsula, 'the Gower' or just 'Gower' to the locals. It is situated on the western boundary of the city of Swansea in West Glamorgan.

This is a climatically favoured area: in summer the inhabitants of the Gower are joined by people from Swansea and thousands of holidaymakers from further afield–all seeking sun, sea and scenery. Even in the average winter the climate is comparatively mild in temperature, though often windy or damp. Frosts are neither frequent nor usually severe, and snowfall (especially with the snow lying for some days) is so rare as to be something of an event. This mild winter climate has a particular impact on the agriculture of the Gower, allowing early crops, especially of potatoes–for which the Peninsula is famous.

The geology–and consequently the soils and habitats–of the Gower are so diverse it is tempting to suggest that nowhere else in Britain could so much variety be found in so small a space (the Gower fits neatly into a rectangle of about 24 by 8km/15 by 5 miles). There can be few areas that offer so much ecologically, both to the general naturalist and to the specialist, coupled with great scenic beauty and rail networks.

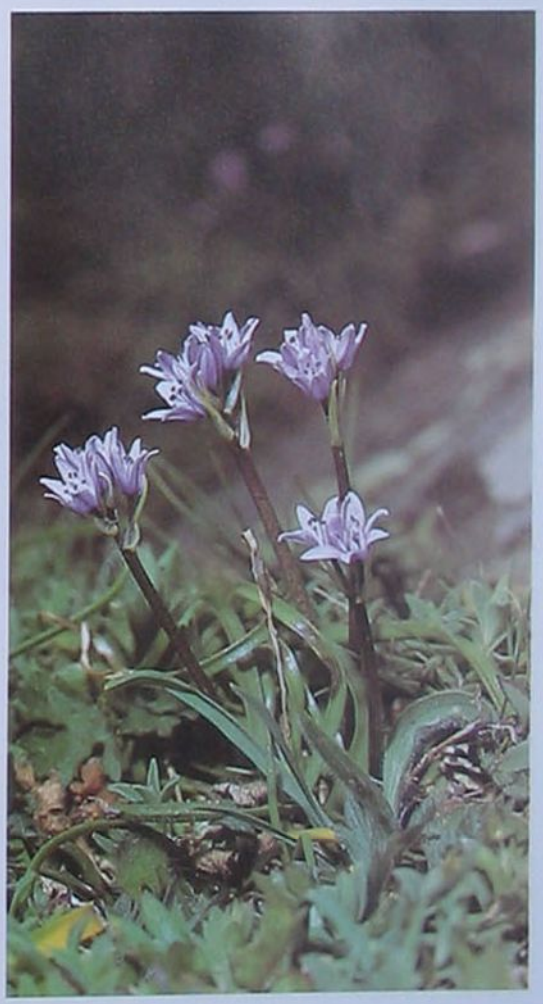
Gower's cliffs The scenic splendour of the Gower is nowhere better seen than on the south coast. Here the spectacular Carboniferous limestone cliffs stretch for miles, their strata in some places running almost horizontally, in others contorted at all sorts of angles by upheavals in the earth's crust throughout geological time. These rock strata are, in essence, the different layers of a sea-bed formed from the chalky skeletons of minute marine organisms deposited over some 50 million years, starting 250 million or more years ago. The angles at which they lie govern the suitability of the rock to make ledges for nesting birds or plant colonies. The serried ranks of headlands and bays stretch from Mumbles, a Swansea suburb, to the Worm's Head at the western tip of Gower.

Many of the cliffs along this coast exceed 30m (100ft) and offer good nesting sites for such birds as herring gulls and jackdaws. Perhaps because of the numbers of holiday-makers, other seabirds are harder to find. The occasional secluded bay holds a kittiwake colony–noisy and smelly and always a hive of activity with nests attached to improbably small out-jutting rocks, often under seemingly impossible overhangs. On the Worm itself there are more kittiwakes, with gulls, some shelduck and, on the tallest sheer north-facing cliffs, mixed colonies of razorbills and also

Opposite page: A view of Worm's Head at the western tip of Gower. This slender rocky promontory is connected to the mainland by a stony pavement for a few hours at low tide; its strange hump-backed appearance makes it easy to see how its name, 'worm', could have been derived from the Old Norse for a sea serpent. The foreground flowers are rock-roses.

Right: Spring squill–one of many flowers to be seen on Gower. Sadly, many species are threatened by improvements to the common grazing land at the top of the cliffs. Seeding with vigorous grasses and heavy applications of nitrogen undoubtedly improve the grazing quality, but at the cost of severely reducing the typical limestone flora.

Below: The vast numbers of shellfish on the sandflats of Gower attract such wading birds as the oystercatcher.



Above: One of the many sights to be seen on the Gower Peninsula–Pennard Castle perched high on the hill, and Pennard Pill.

of guillemots.

The cliff plants are not quite so much influenced by people as are the birds, and the mild climate, linked with the limestone-based soil, gives rise to an excellent and colourful flora. Much of the colour comes from a spectacular profusion of relatively common plants–thrift, squill, thyme, daisy and rock-rose–but there are other attractions, including the multi-coloured basil-thyme and early purple and green-winged orchids. If you look closely at the rock-roses, you will see two types, one smaller and paler in flower than the other; this smaller one is the rare hoary rock-rose. Most special of all, perhaps, is the yellow whitlowgrass, clinging like a yellow-flowered saxifrage to the shallow layer of soil in a crack halfway up a rock face. This is an isolated relic, cut off and somehow surviving on these cliffs during the Ice Ages: its nearest other colonies are in Portugal.

Caves, beaches and dunes The abundant sea caves along this coast also house some relics, although most are now in local museums. Some of the caves offered sufficient shelter to be used by wild animals in the past–as they are occasionally by sheep today–and because of the relics left when these ancient animals died they are called 'bone caves'. Among the animals found in them are elks, mammoths and woolly rhinoceros–clear indication that the climate of the Gower was once considerably less favourable than today.

At the base of the cliffs, extensive sandy beaches attract holidaymakers. Biologically these beaches are rich in shellfish and, together with the many rock-pools, offer plenty of scope for the marine biologist. At low tide rocky reefs are exposed in some areas, the soft limestone deeply eroded and holed by the action of the water and offering a multitude of hiding places for lobsters and crabs. On the rock surface a plentiful covering of seaweeds provides concealment for the small shore animals on which turnstones and purple sandpipers feed.

Across some of the larger bays extensive sand dune systems have formed, clad in marram grass and with surprisingly pre-

Below: Some rather special plants can be seen on the Gower in mid-summer. One such is the attractively named goldilocks (shown here), and another is the small rest harrow. These are two of Britain's rarer plants.

cipitous slopes for so unstable a medium. Perhaps the most spectacular is Whiteford Burrows, best viewed from the raven's-eye view on top of Rhossili Down, but here the scenic impact is marred by a sprawl of caravans. Better known is Oxwich, a National Nature Reserve. Here a typical sand dune flora is enriched by an abundance of orchids, including marsh helleborine, while behind the dunes, in the 'dune slacks', an excellent marshland has developed. As it is based on limestone the marsh is rich in many forms of wildlife besides plants. Newts and dragonflies abound, and resident and migrant birds flourish, with the appearance, every so often, of a real rarity such as a little bittern.

Woods and uplands On its inland margins Oxwich is surrounded by one of the relatively few wooded areas of Gower. If any major habitat type is poorly represented in Gower, then it is woodland. Even conifer plantations are almost lacking, while deciduous trees are mostly to be found in narrow belts beside roads, along the courses of streams or in the deep and often dry valleys running down to the coast. Judging from the numbers of garden and scrubland birds, this lack of trees does not have a dramatic effect on the bird population, and larger species–crows, ravens, buzzards and sparrowhawks–seem to find nest sites without undue difficulty. Of the deciduous trees, it is the sycamore that impresses most. This tree is widespread, often with a carpet of arum and wild garlic beneath its branches; some have reached considerable stature and relative antiquity, to judge from their gnarled appearance and hoary fringes of lichens.

The Gower uplands are as acid as the south coast is alkaline with its limestone soils. Cefn Bryn and Rhossili Down are the highest points, each with an extended ridge running north-west/south-east. In some exposed parts near the old beacon sites the vegetation is almost alpine in appearance, with stunted heathers and ling predominating.

Birds here are few and far between; there are meadow pipits, wheatears and stonechats in the gorse of sheltered spots, and overhead passing ravens and buzzards. To the

Above: Fulmars are on the increase in Gower (as elsewhere), and on windy days their flight prowess can be observed with ease, and at very close quarters, from a number of cliff-top vantage points, such as Thurba near Rhossili.

Above right: Basil-thyme in bloom–such plants as this flourish in the relatively mild climate prevalent on the Gower.

east of Cefn Bryn lies a huge high-level boggy area, the swampiest parts bright with the colours of sphagnum moss. Botanically this is a fascinating region, with such specialist plants as the insect-eating sundew, and attractive ones like the minute pink bog pimpernel, the striking golden spikes of bog asphodel and the feathery white plumes of bog cotton. This is meadow pipit country, too, with skylarks singing over the drier areas and the occasional curlew yodelling its breeding season song in the damper parts. In high summer cuckoos often abound, with plenty of pipits to foster their young and 'woolly bear' caterpillars for food.

The north coast The north coast of the

The Gower Peninsula

cliffs
sandy beaches
sand dunes
marshland
mudflats
woodlands
uplands
nature reserves
National Trust

It is unfortunate that no area in Britain today is entirely free from threat. In the Gower the farmland is excellent, but as pesticides and herbicides are more widely used in intensive agriculture such plants as hedge parsley, campion and bloody crane's-bill vanish from the fields–and with them the butterflies as well. Rock climbers inevitably disturb cliff birds, and holidaymakers place such delicate environments as the Oxwich dunes under extreme pressure–making good management difficult without antagonism.

Above: Rest harrow–a plant to look for on the limestone grasslands of the Gower. It flowers from July to September.

Gower is vastly different from the south. The bulk of the Gower forms a gigantic breakwater, protecting the Burry inlet from the wind and waves sweeping in from the south-west; in this shelter huge sandflats have formed, stretching away into the haze at low tide. The flats are dissected by deep cracks or runnels, making this a place to proceed with caution since the flooding tide sweeps in very smoothly but very rapidly. To be cut off as the tides comes in could prove to be dangerous.

The sandflats house uncountable millions of shellfish and at low tide, particularly during the winter months, they are dotted with gulls and waders seeking food. The cockle population is sufficiently high for a local industry to flourish. The cockle fishers rake the shellfish from the sand with special forks and often take their harvest back to the shore with the aid of a horse and cart. Not surprisingly, such a density of shellfish has also encouraged large numbers–often thousands, sometimes tens of thousands–of oystercatchers, giving rise to fears that the birds might deplete the shellfish stocks to such a degree that the industry would be put out of business. As all too often happens, sadly this situation periodically develops into one of direct conflict between the cockle fishers and conservationists opposed to the view that the only solution to the problem is a wholesale slaughter of the oystercatchers.

The northern Gower coast is essentially a wild, remote and lonely place, characterised by the bubbling trill of the curlew or the soulful call of the grey plover. Usually only cattle and horses, grazing the nutritious grasslands washed by the highest tides, disturb the waders on the flats, but occasionally a peregrine dashes through, sending redshanks into noisy hysteria and scattering the dunlin, which regroup away in the distance looking like wisps of smoke.

Below: Spectacular cliff and sea scenery on the Gower coast. Such sites attract large numbers of seabirds.

RARE BUTTERFLIES BLOWN TO BRITAIN

From time to time rare migrant butterflies reach our shores in unusually large numbers. Most of them come from southern Europe, although one species – the spectacular monarch – is carried by westerly winds all the way from North America.

Above: You are more likely to spot the pale clouded yellow (*Colias hyale*) than the other rare migrant butterflies, although sadly it has become less frequent recently. Good years for the pale clouded yellow tend to coincide with good years for the clouded yellow (a more common migrant), obviously a result of the same weather conditions favouring both species. 1900 was the best year ever for the pale clouded yellow, when more than 2000 specimens were recorded.

No-one knows for certain why migrant butterflies arrive here in such large numbers in some years and then are hardly seen again for many years. However, among various probable explanations is the degree of breeding success in the main breeding grounds around the Mediterranean. A large build-up of the local population inevitably leads to a northwards movement by many individuals in search of fresh sources of nectar-rich flowers. Having moved further north in Europe some of the butterflies may then be caught up in weather conditions near the coast which transport them to Britain on strong winds.

There is also evidence that, on some occasions, the butterflies become involved in abnormal weather conditions much farther south, so they are carried here directly on warm airstreams from north-west Africa and Spain.

Rare yellows The pale clouded yellow is one of the more frequently seen rare migrant butterflies, its good years tending to coincide with the good years of the more common clouded yellow – also a migrant. Unlike those of some migrant butterflies, the caterpillars of the pale clouded yellow can survive our winters, especially a mild one, so those which do not pupate before winter sets in can hibernate as caterpillars and then pupate the following summer.

Another rare migrant, Berger's clouded yellow, is difficult to distinguish from the pale clouded yellow. The male Berger's clouded yellow is usually a brighter yellow, however, and both sexes are less heavily marked with black at the tip of the forewings.

A rapid flier, Berger's clouded yellow arrives in England in late summer and autumn, when the female lays her eggs on horseshoe vetch and crown vetch. The caterpillars can survive a favourable British winter.

The Bath white A particularly rare and irregular immigrant from the European mainland is the Bath white. Normally only a few individuals appear here, at intervals of several years, but 1945 will long be remembered as the great 'Bath white year', when no less than 650 specimens were

Above: The Queen of Spain fritillary (*Argynnis lathonia*) often settles on the ground, where it is easily recognised by the large, bright silver blotches on its undersides. In the British Isles you are most likely to see it between May and October.

Left: The Bath white (*Pontia daplidice*) derives its English name from an 18th century specimen which was caught near Bath, and used by a young lady of that elegant city as the subject for a piece of embroidery.

Below: Berger's clouded yellow (*Colias australis*) is difficult to distinguish from the pale clouded yellow, although it is usually a brighter yellow with less heavy markings.

recorded. In that summer they became common in the Channel Islands, and in July crossed the English Channel on a broad front, arriving all along the south coast from Kent to Cornwall. Some were sighted as far north as Lincolnshire and a few even reached south-west Ireland in October.

On the wing the Bath white could be mistaken for a green-veined white or a female orange-tip, but when seen at close quarters, the big squarish black spot in the centre of the forewing and the greener undersides and white mottling of the hindwings are distinctive.

The Bath white usually frequents open ground, where the female lays her pinkish-yellow eggs singly on the flowers of mignonette and such cruciferous flowers as hedge mustard. These hatch into rather hairy, bluish-grey caterpillars with yellow longitudinal stripes and numerous black shiny warts.

A regal fritillary The Queen of Spain fritillary is as rare and irregular an immigrant to Britain as the Bath white. Very few specimens have been reported since 1950, but 1945 was a particularly good year, with 37 sightings. Most Queen of Spain fritillaries arrive in south-east England, especially Kent, but they have been recorded as far west as Cornwall; there are only two Irish records.

The caterpillars, which feed on wild pansies and violets, have only been found in England on two occasions this century.

Three rare blues The year 1945 was also an exceptionally good one for the immigration of long-tailed blues–that summer 31 were recorded in southern England, mainly along the coast. Since 1945 they have been a great rarity.

The true home of the long-tailed blue is the Mediterranean region, where it is common, appearing in a succession of broods throughout the year. Not surprisingly, it is unable to withstand the British winter.

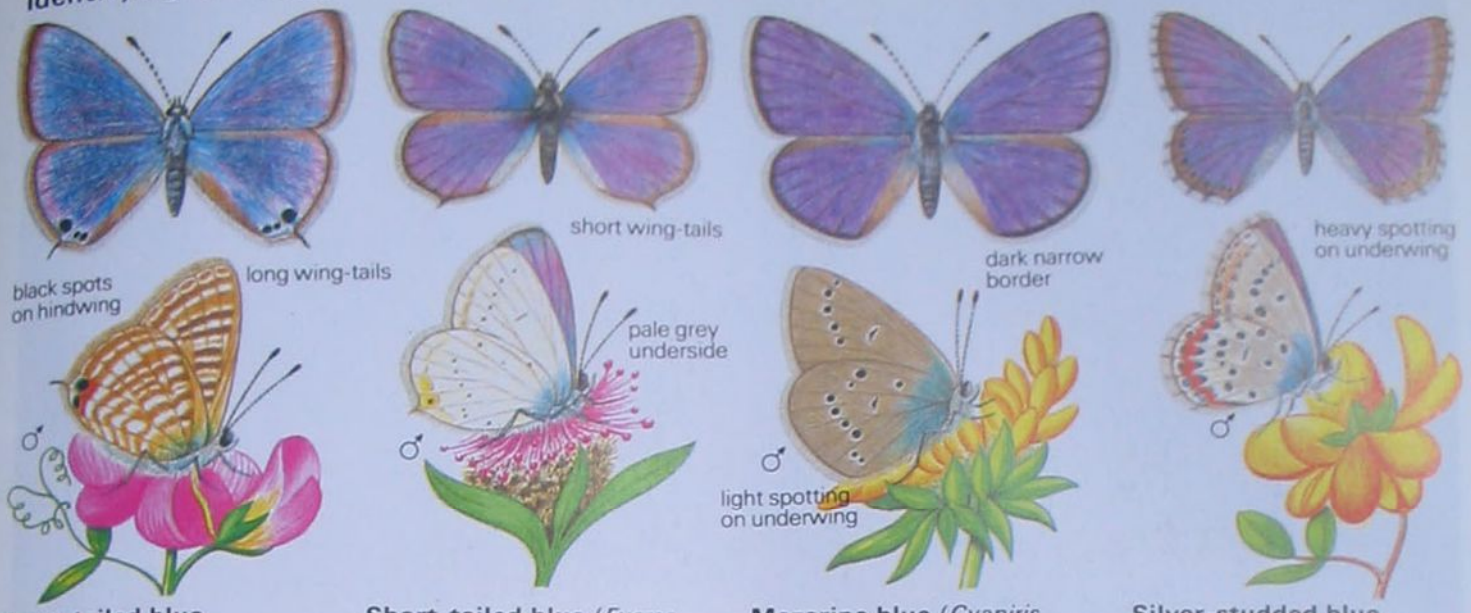
Two short-tailed blues, a male and a female, captured in 1874 in Somerset, constituted the first record of this central and southern European butterfly. Only ten have been reported since then, mostly in the south-west on dunes, downland and heathland. The majority of those seen arrived between July and September, but sadly they did not breed here.

Another similar looking species, the mazarine blue, used to breed in England and Wales, but died out at the end of the 19th century; nowadays it only occurs as an extremely rare migrant from the European mainland.

Northern migrant The Camberwell beauty differs from the other migrant butterflies in coming from northern rather than southern Europe. Consequently this species is as likely to be found in the north of Britain as in the south.

Although some individuals probably hitch a lift on ships, most fly directly across the North Sea in response to particular anti-cyclonic weather conditions over Scandinavia

Identifying the blues



Long-tailed blue (*Lampides boeticus*), wingspan 3-3.5cm (1-1¼in), rare migrant from the Mediterranean.

Short-tailed blue (*Everes argiades*), wingspan 2.5cm (1in), rare migrant from central and southern Europe.

Mazarine blue (*Cyaniris semiargus*), wingspan 2.8-3.4cm (1-1¼in), rare migrant from mainland Europe.

Silver-studded blue (*Plebejus argus*) 2.4-3cm (1in), common resident in southern England and Wales.

and their associated easterly winds–a factor which would account for the irregularity of their visits to Britain. Thus although there are long periods in which few, or even none, have been reported, occasionally large immigrations take place. In the hot summer of 1976 such an immigration was witnessed, with about 300 Camberwell beauties arriving on our shores.

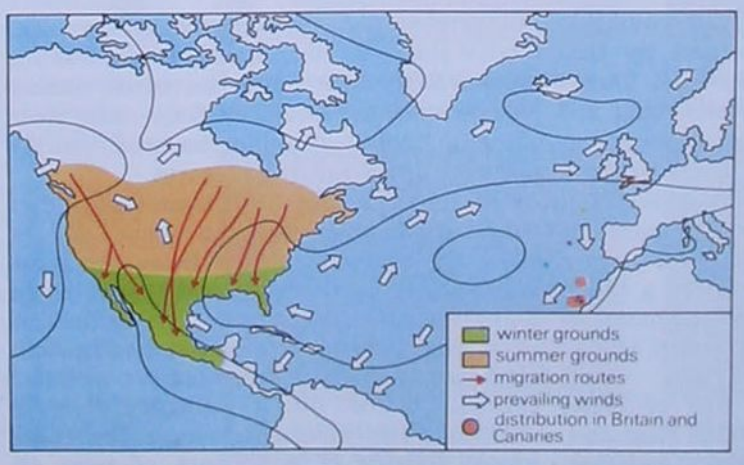
Monarch from North America Since the first monarch butterfly was captured here in September 1876, more than 300 have been sighted in the British Isles, with peaks of 40 in 1933 and 65 in 1968. The largest invasion of all, however, took place in 1981, when an unprecedented number of monarchs were carried some 3500 miles across the North Atlantic on strong westerly winds.

Altogether 130 sightings were made, although it is not precisely known how many butterflies were actually involved. On the Scilly Isles that October some were even seen roosting in Monterey pines.

Right: The Camberwell beauty (*Nymphalis antiopa*) is a rare migrant from northern Europe so, unlike most of our other rare migrants, it is sometimes seen in the north of Britain. An unmistakable butterfly, it owes its name to the discovery of the first British specimens near Camberwell (then a village near London) in August 1748. Today the butterfly is often attracted to garden buddleias as well as to over-ripe fruit. Occasionally Camberwell beauties hibernate in Britain, but they have not succeeded in pairing in spring–a point established by the fact that their caterpillars have never been seen here.

Atlantic crossing

In some years monarchs (far right) are blown off their North American autumn migration routes into the Atlantic by offshore gales. Here they are caught up in the prevailing westerlies associated with deep depressions, and carried across to Europe in a few days. Many perish, but the majority of those that reach land do so in south-west England–and the Canaries.



THE STRANGE WORLD OF SLIME MOULDS

At one stage in their lives behaving rather like a giant amoeba and at another like a typical spore-producing fungus, slime moulds are surely the strangest organisms found in the British Isles–so strange, indeed, that scientists cannot even decide whether they are plants or animals.

Above: One of the most common and conspicuous slime moulds is *Physarum cinereum*, which forms bright yellow patches that may be as much as 30cm (1ft) across. The specimen shown here is in its mobile, feeding stage, called the plasmodial stage. In a few days time, this slime mould will pass into a reproductive stage, producing yellow club-shaped fruiting bodies that will eventually turn grey and release their spores. The stages in this startling transformation are shown on the opposite page.
Slime moulds are more common than many people realise. In May 1981, the British Mycological Society made a foray into the Forest of Dean during which 45 different species of slime mould were discovered, while a marshy bed of osiers near Gloucester revealed 14 different species without any intensive searching.

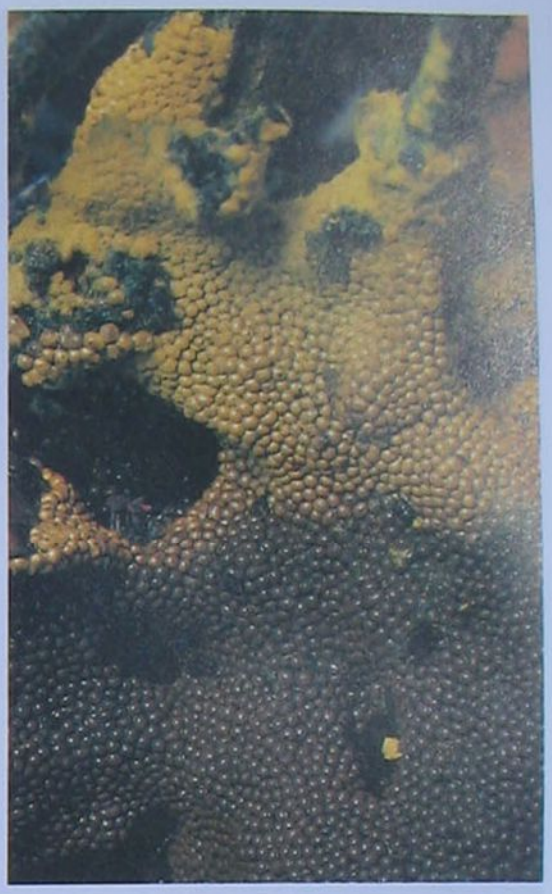
Although not uncommon in this country, slime moulds are seldom noticed by the general public. Even biologists–who know these organisms as myxomycetes–tend to know little about them for they cannot agree on the position they occupy in the natural world. Their identification is undertaken by mycologists, whose proper study is fungi, yet slime moulds are not true fungi.

The problem lies in the fact that a slime mould exists in two very distinct phases: a mobile feeding phase and a stationary reproductive phase.

Creeping plasmodium The first of these phases is known as the plasmodial stage and has many characteristics in common with that primitive animal, the amoeba. In the plasmodial stage the slime mould feeds, flowing imperceptibly over damp leaves or rotting logs on a shaded woodland floor–their most common habitat–engulfing bacteria, moulds and even larger fungi as it moves.

During this stage, the plasmodium often forms a beautiful fan-like shape and is strikingly coloured, yellow being the most common. A typical and widespread slime mould is *Physarum cinereum*. This species can form large, bright yellow patches nearly 30cm (1ft) long and resembling splashes of paint carelessly daubed over a rotting log.

During the plasmodial stage the slime mould consists of a network of veins all



creeping forward in the general direction of a thickened and curved leading edge. Within the plasmodium, cytoplasm streams along this network of veins, usually but not always travelling towards the front so that the organism gradually moves forward in a series of pulsations, rather like the tide gradually coming in. The forward movement of the slime mould is so slow that, to the casual observer, it seems not to be moving at all, yet a return visit to the site the following day will show that the leading edge of the plasmodium has advanced across the substrate. The actual speed of flow varies a great deal with the temperature, light, moisture and the amount of food available.

Stopping to make spores After the plasmodial stage the slime mould undergoes a startling transformation. It stops moving and globular droplets begin to form along the front edge and some of the denser veins. These develop into sporangia–the spore-containing bodies of the mould, which now enters into its second, reproductive, stage. The sporangia gradually ripen–depending on the species they may also change colour–and the spores are dispersed by a puff of wind or by the sporangia being touched.

In *Physarum cinereum* the whole cycle may take only a day or two, so if you see a specimen in its plasmodial stage it is worth returning to it regularly as it changes and matures.

Above: A great many slime moulds are much more attractive at certain stages of their development than at others. An example is *Trichia deciphens*, whose immature sporangia resemble tiny glistening pink pearls on short white stalks. But they do not remain like this for long. By the next day the sporangia will have matured to a much less attractive black.

Right: In contrast to the above slime mould, this species of *Trichia* is at its most attractive when mature. The sporangia are brown when young but ripen to become yellow.

Growth of a slime mould

In its initial, plasmodial, stage the slime mould *Physarum cinereum* is shaped roughly like a broad fan with an intricate network of veins running towards a thickened leading edge (see picture on opposite page). Within perhaps a day or two, globular droplets begin to appear at the front edge of the mould and along its larger veins (**1**). Gradually these droplets elongate as the protoplasm inside coalesces into groups of club-shaped structures called sporangia (**2**). These are the slime mould's fruiting bodies. Soon these clubs develop into globular structures and cluster together so that they look like bunches of tiny grapes (**3**). These globular sporangia contain myriads of tiny spores. Within a few hours they darken and turn ash-grey as the spores inside ripen (**4**).

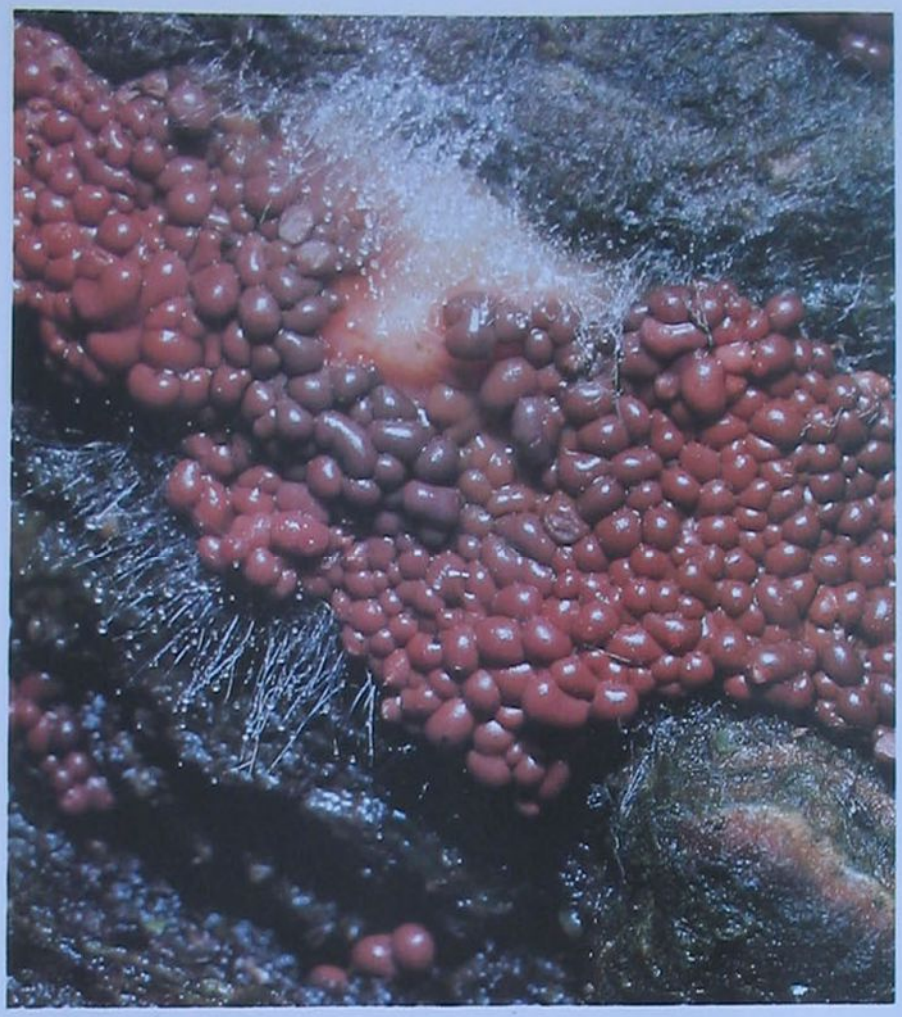
The sporangia are now ready to release their spores–all that is needed is the slightest touch or a puff of wind for the microscopic spores to be wafted into the air to colonize a new site.

1 The first sign of change is the appearance of globular droplets.

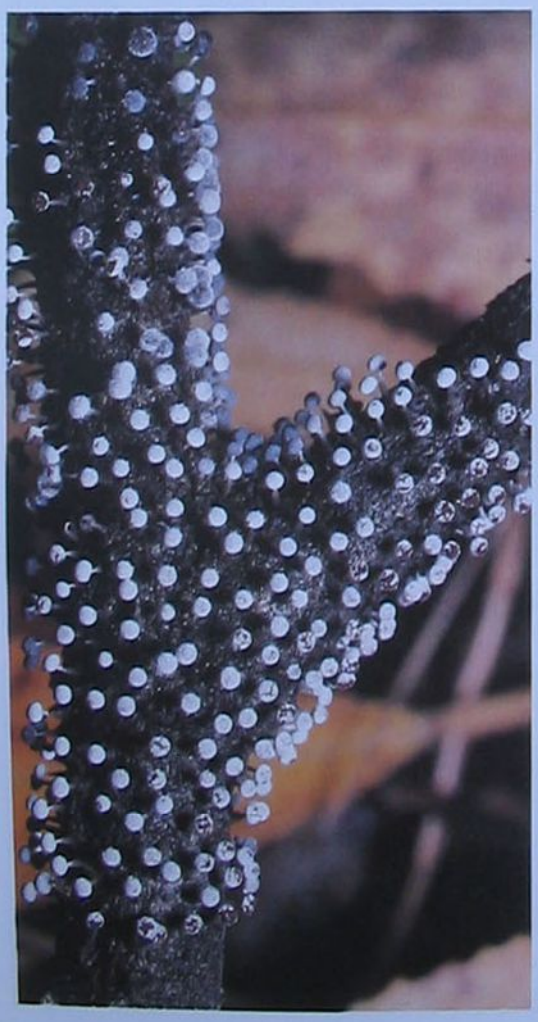
2 The droplets elongate to form club-shaped fruiting bodies.

3 The fruiting bodies cluster together as they ripen.

4 When ready to release their spores the bodies turn ash-grey.



Above: One of the rarest slime moulds in Britain is *Arcyodes incarnatus*, which lives on rotting wood. It appears as a dense mass of shiny, reddish blobs looking rather like miniature kidneys, crammed into the furrows of dead wood. Each blob is a maturing sporangium and measures less than 12mm (½in) across.



Left: In general, the best places for finding a slime mould are rotting tree stumps and logs, particularly in damp, shady places. Some species, however, are not especially fussy about their habitat. *Physarum nutans*, for example, can be found on living wood (as shown here) and it often appears in some numbers overnight on a lawn or among a pile of prunings. This species appears as greyish-white rounded heads borne on short dark stalks. As they ripen the heads become darker and powdery with the presence of spores.

Conspicuous plasmodium Like *Physarum cinereum*, many other slime moulds are most conspicuous during their plasmodial stage. One of the most beautiful is *Leocarpus fragilis*, a characteristic species of pinewoods where, in autumn, it may be very common. It forms vivid yellow patches which, in the prevailing gloom beneath the pine trees, may be visible from some distance. The mass of yellow plasmodium crawls across a brown carpet of fallen needles, twigs and cones before entering its second phase and developing a tightly packed mass of club-shaped sporangia which turns a bright bronze colour.

A number of *Badhamia* species are common in Britain, often growing on dead wood, fallen elms being especially favoured if there is enough shade and humidity for the wood to remain moist. Other species of *Badhamia* are found on grass, for example *B. foliicolia*. This slime mould forms a yellow plasmodium that may be more than 30cm (1ft) across when colonizing a favourable habitat such as a damp shaded pile of rotting grass clippings. Within a matter of hours the plasmodium turns into thousands of small globular sporangia, which blacken and then become pale grey as they ripen.

Hidden plasmodium A number of common slime moulds, such as species of *Stemonitis*, have a concealed plasmodial stage that lives inside rotting wood. The first sign that there is a slime mould fungus inside is when small drops of a creamy glistening liquid appear on the surface of the wood. These blobs coalesce and grow into a stout column and then into a cluster of cylinders–each constituting a distinct sporangium–supported by thin black stalks. All the while its colour darkens almost to black. Its delicate outer wall then dries out and the spores are dispersed by the wind.

One species in this genus, *Stemonitis fusca*, has chocolate-brown sporangia almost 2.5cm (1in) long supported by stalks about a third of that length. Large aggregates of this species' fruiting bodies can often be found almost completely covering the damp top of a rotting log. The long thin sporangia frequently fall over under their own weight as they release their dense clouds of brown spores. The effect can be as though someone had spilt a large jar of powdered coffee over the log.

A much smaller species in the same genus is *Stemonitis herbatica*. It bears tiny clumps of pinkish-brown sporangia on short black stalks. Eack clump has a similar shape to a power station's cooling tower.

Massed sporangia Some slime moulds take the crowding of their sporangia to an extreme. In species of *Tubifera*, for instance, the sporangia are so tightly massed together that they are partly joined to one another and form large compound structures known as aethalia.

The aethalia of one such species, *Tubifera ferruginosa*, can often be found on fallen trees in the autumn. At first glance, the aethalia

looks like a simple, round, orange or pinkish blob. A closer examination reveals a mass of slim sporangia crowded together. The aethalia turns black as the sporangia ripen and release their spores.

A very similar looking species, though in a different genus, is *Lindbladia effusa* var. *simplex*, whose bright orange-pink aethalia can often be seen sprouting through cracks in the bark of fallen trees.

Colour changes The change in colour as fruiting proceeds is often extremely marked. The sporangia of the very common *Arcyria denudata*, for example, appear as glistening white clubs when young but change within a day or two to a striking crimson colour as the spores are released from the now rather fluffy surface. This species often grows on rotting logs and stumps, frequently accompanied by another equally common slime mould, *Comatricha nigra*. In this species the sporangia first appear as tiny elongated white outgrowths with thickened tips. During the course of a day these develop into pale pinkish-brown, sausage-shaped structures on long black wiry stalks. The sporangia then change through dark brown to black and finally to chocolate brown as the spores are released.

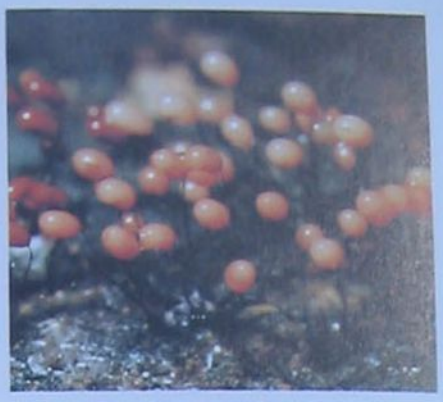
Perhaps the species of slime mould most often noticed by the general public is *Mucilago spongiosa*. The plasmodium of this species looks like a mass of frothy cream that someone has spilled on the floor–it is usually seen on grass, often around the base of a sapling tree. In this species the plasmodium hardly breaks up at all, instead it slowly changes colour to a featureless ash-grey patch as the dusty spores are released. In a warm, damp autumn it can be extremely abundant on grass, dead leaves and pieces of wood.

When and where to look Slime moulds can be seen throughout the year, though spring and autumn are the best times to look. Several species also grow and fruit during a damp spell in mid-summer or during mild wet weather in winter.

Damp, shady places are usually the best places to look, in particular the tops and undersides of logs–especially when the wood is in an advanced state of decay, and soft and pulpy; damp, fallen leaves and rotting tree stumps are also excellent hunting grounds.

Cancer cure? Given the appearance of slime moulds they hardly seem likely to have any connection with cancer. Yet researchers in America are using slime moulds to investigate how cancer develops. It seems that sporulating slime moulds 'switch on' certain genes for spore formation while other genes necessary for growth are 'switched off'. This switching on and off of genes probably also occurs during the mutation of a normal cell into a cancer cell. By learning how a slime mould changes from one phase to the other, it may be possible to gain some insights into the causes of cancer in humans.

Slime moulds–young and old



Above: *Comatricha nigra* appears first as elongated white outgrowths (left) which mature into brown sporangia borne on long wiry black stalks (right).

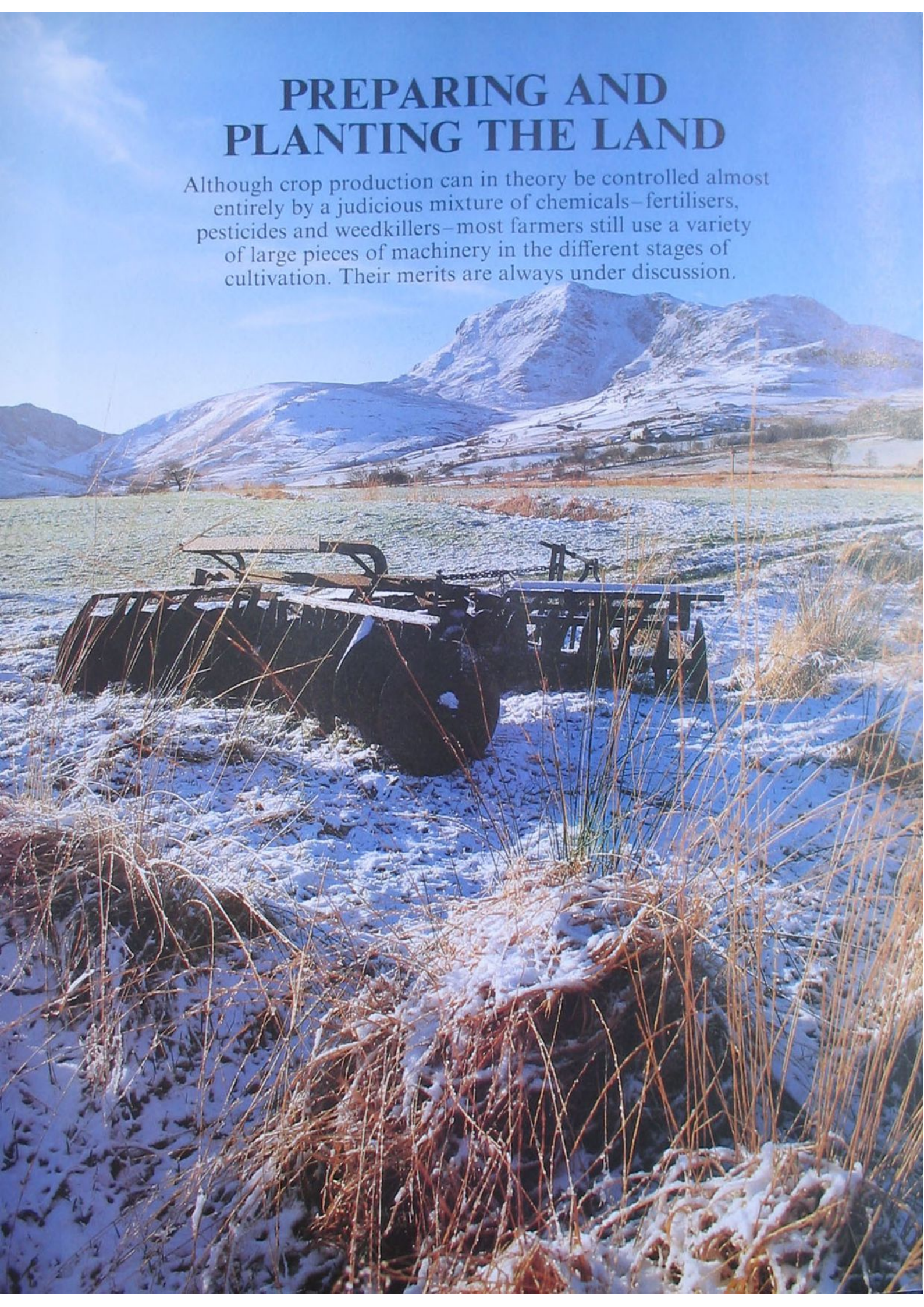
Above: The glistening immature sporangia of *Leocarpus fragilis* (left) mature to a shade of reddish bronze (right).

Above: The young sporangia of *Stemonitis fusca* aggregate into stout columns (left) which disintegrate when the spores are released (right).

Above: The massed sporangia of a young *Reticularia lycoperdon* (left) turn a dark chocolate-brown as the spores are released (right).

PREPARING AND PLANTING THE LAND

Although crop production can in theory be controlled almost entirely by a judicious mixture of chemicals–fertilisers, pesticides and weedkillers–most farmers still use a variety of large pieces of machinery in the different stages of cultivation. Their merits are always under discussion.



Farmers cultivate the land for four reasons: to clear crop debris, to incorporate manure, to kill weeds and to achieve a properly drained and aerated granular soil structure, or 'tilth'. Traditionally these objectives are attained by physical means. After the harvest the land is turned over by the plough; weeds, manure and rubbish are buried, and the resulting clods are then broken down by a variety of harrows and rollers, combined with the shattering effects of frost action and alternate wetting and drying. The repeated working encourages the germination of weeds so that they can then be destroyed, and by the time the land is ready for the seed the decaying vegetation is adding to the fertility of the soil.

This is the classic way of cultivating the land, but it has no intrinsic merit. The development of artificial fertilisers, pesticides and weedkillers has made much of this activity unnecessary, and by using chemical methods farmers can establish the crop in two or three swift workings over the land, so saving time and energy. But these techniques are still the subject of experiment and debate; consequently each farmer tends to oscillate between tradition and novelty, depending on the current climate of opinion.

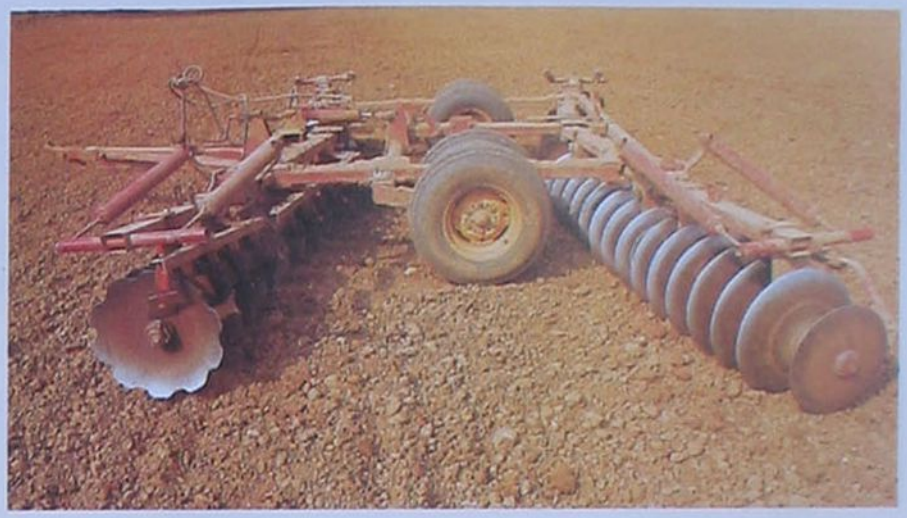
The plough The principal implement of traditional cultivation is the plough. Designed to cut out a slice of soil and turn it over, it consists basically of a disc coulter–a vertical rotating blade which separates each slice from its neighbour, a share–a horizontal blade which undercuts it–and a curved mouldboard to lift and invert it.

The precise shape of the mouldboard determines the effect on the soil: the gleaming furrow slice, beloved of Victorian ploughmen and poets, came from the lea plough.This plough had a long, smoothly twisting mouldboard that preserved the slice in one piece and pressed it firmly against its predecessor to smother weeds. Most ploughs today have a more aggressively curved, or even slatted, mouldboard to break up the slice of earth and reduce the work required to produce a seedbed. Now that chemical weed control is available, the farmer's main concern is to get the crop in the ground before the winter rains make cultivation impossible.

A single ploughing implement consists of between three and ten such plough bodies along a diagonal plough beam that is linked to the tractor's hydraulic three-point mounting. By this mounting the plough is automatically raised and lowered to cope with ground irregularities, and the implement can be raised well clear of the ground to allow the driver to back right up to the hedge before starting the next furrow; had this mechanism not been widely adopted in the 1930s our hedges would have disappeared long ago.

Cultivators and harrows The main function of the mouldboard plough is to bury crop remains and weeds, and to incorporate manure. It is therefore useful on, say, a dairy farm where feed barley and maize are often grown on fields which were previously well-manured grassland. To an intensive cereal grower its value is doubtful. Here the land is fertilised artificially and of the crop remains only the roots make a valuable contribution to the condition of the soil. Raw stubble takes time to decay and contains little goodness, so it is usually burnt. Having done this, many farmers leave the land much as it is, rather than turning it all over–at considerable expense–exposing the plant roots and risking the loss of plant nutrients by oxidisation.

This theory forms the basis of the technique known as minimum cultivation. In its extreme form it involves drilling the seed directly into



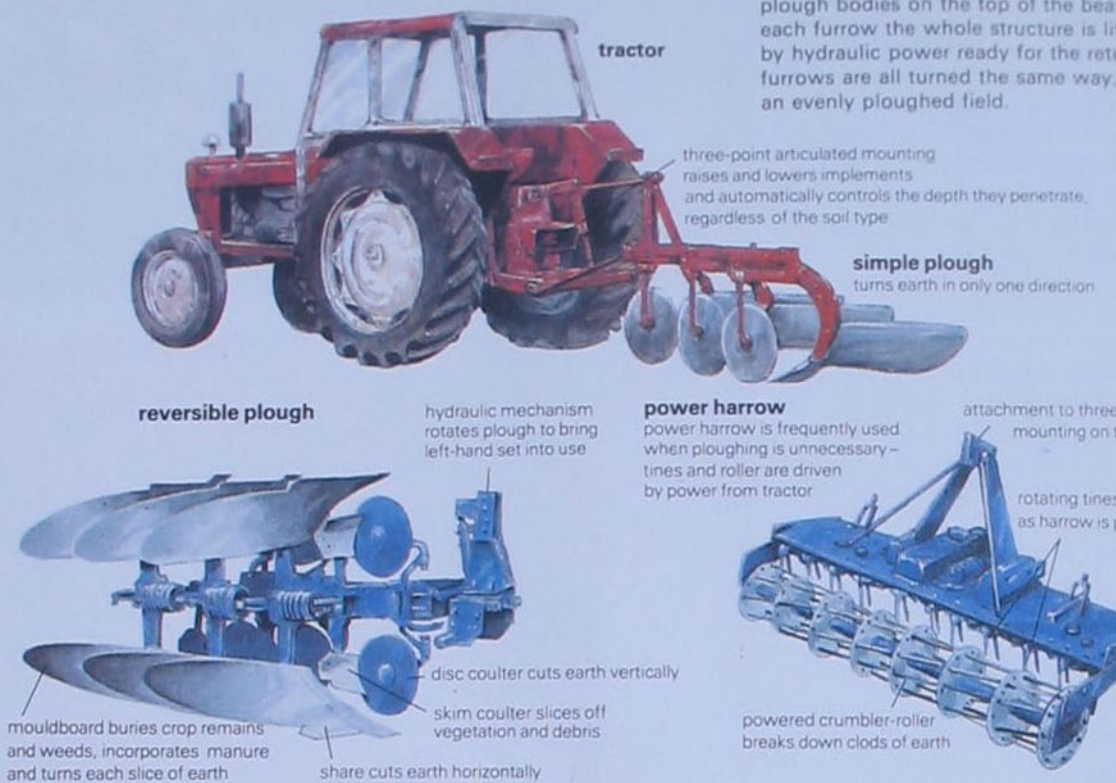
Top: A modern reversible plough is both left-handed and right-handed so that as a field is ploughed up and down each furrow matches the one on either side.

Above: A disc harrow breaks up the earth and disturbs weed seeds; they sprout, and can then be sprayed and destroyed.

Below: A spring-tine harrow is another implement used to break up clods of earth left by the plough.

Turning over the land

Tractors have articulated mountings so that implements, such as the reversible plough, may be controlled. A simple plough turns the furrow to the right, working steadily up and down the field, producing gullies and ridges where adjacent furrows clash. A reversible plough has a second set of plough bodies on the top of the beam; at the end of each furrow the whole structure is lifted and rotated by hydraulic power ready for the return run. The furrows are all turned the same way, so producing an evenly ploughed field.


tractor
three-point articulated mounting raises and lowers implements and automatically controls the depth they penetrate, regardless of the soil type
simple plough
turns earth in only one direction
reversible plough
hydraulic mechanism rotates plough to bring left-hand set into use
disc coulter cuts earth vertically
skim coulter slices off vegetation and debris
mouldboard buries crop remains and weeds, incorporates manure and turns each slice of earth
share cuts earth horizontally
power harrow
power harrow is frequently used when ploughing is unnecessary – tines and roller are driven by power from tractor
attachment to three-point mounting on tractor
rotating tines stir up field as harrow is pulled forward
powered crumbler-roller breaks down clods of earth

undisturbed soil, but normally the ploughed surface is broken up by a tined cultivator or a disc harrow. This disrupts the crust that tends to form on arable land (which has a relatively poor vegetation cover and is easily 'panned' by heavy rain); and it disturbs annual weed seeds, encouraging them to sprout. They are then killed by spraying with a contact herbicide, such as paraquat, which burns off the foliage while leaving the roots intact. It does not penetrate the soil, and it may be that such chemical weed control has a less drastic effect on soil life than the wholesale disruption caused by traditional methods.

The disc harrow consists of a battery of circular blades that rotate as they are drawn over the ground. Originally designed to break up the clods created by ploughing, it has proved a most efficient and flexible cultivation tool. The blades are arranged in sets, angled to the direction of travel; the greater the angle, the deeper it bites, but a bigger tractor is needed to pull it.

The cultivator is a crude implement by comparison, being merely a number of strong tines bolted to a tractor-mounted toolbar. It is particularly effective on light, friable soil which shatters on impact, and is in fact a heavier version of the clod-shattering harrow which is found on every farm. This latter device is usually equipped with spring-loaded tines; drawn rapidly across land which has been previously disced or cultivated, its kicking action produces a rough seedbed ideal for a crop such as wheat. A finer seedbed may be achieved using a zig-zag harrow which has a number of prongs mounted in staggered formation on a light lattice frame. The finishing touch may be given by the Cambridge roll, consisting of a large number of freely rotating metal rings which produce a characteristic ridged effect on the land. Stones are pressed into the soil and the level surface which results helps in both establishing and harvesting the crop.

All this activity is naturally very time-consuming and it can lead to subsoil compaction. It is not uncommon, therefore, to see two or three different implements hitched in

Below: Liquid manure–slurry– is animal manure mixed with the waste water from washing down livestock housing. This is pumped into a reservoir or 'slurry lagoon' and eventually sprayed on the land from a tanker in a single jet. It is an operation best observed from a distance. Farmyard manure–dung and straw–is also used as fertiliser, and distributed from a muckspreader.

tandem. An alternative is to use a power harrow that has rotating tines and a powered, slatted crumbler-roller which prepares a seedbed in just one pass over the land.

Despite such precautions the continued passage of heavy machinery over the land eventually leads to compaction and drainage problems. A hard pan forms beneath the cultivation level, which must be broken up if the crop is to thrive. For this purpose the farmer uses a subsoiler, a steel wedge mounted at the foot of a vertical blade. Drawn through the subsoil by a powerful four-wheel drive tractor, it breaks up the hard pan and allows standing water to drain away.

Feeding and planting Well-cultivated land is of little use if it lacks the necessary plant nutrients. The roots and foliage of weeds, ploughed-up grassland and crop remains are an important source of these, and so is animal manure, whether scattered by the animals themselves or by a muckspreader.

There is rarely enough animal manure produced on the farm to replace wholly the plant food removed from the soil by intensive cropping. Consequently every farmer uses manufactured fertiliser, normally in the form of dry granules which are scattered by a broadcaster. This is not a particularly accurate device: coverage may be incomplete or uneven and much fertiliser may end up in the ditch or under the hedge. There it is lost to the farmer and merely serves to upset the hedgerow ecology. One remedy is a pneumatic applicator which delivers the granules through a row of boom-mounted nozzles. Alternatively liquid fertiliser may be applied using a sprayer. This is less precise but more popular because it requires no specialist equipment.

Having fertilised and cultivated the land, the farmer is ready to sow the seed. This may be done using a broadcaster, but a seed drill is usually preferred. Essentially this is a number of tubes, arranged side-by-side, which deliver seed (and fertiliser if required) into slots opened by a corresponding set of light disc coulters or tines. Direct drilling into unbroken land requires a more heavily built machine, but the principle is identical. The seed is contained in a hopper spanning the full width of the implement and delivered automatically. For critical application the seed mechanism is designed to place seed accurately at predetermined intervals–a useful device in planting a regularly spaced crop.

Some crops, such as Brussel's sprouts, are raised under glass and planted as seedlings, when they need careful handling. Fully automated mechanisms are complex and expensive and can only be justified by a big investment in the crop. Consequently in vegetable-growing areas it is still common to see semi-manual transplanters in action. These have several operators who travel on the back of the machine, feeding the plants between pairs of rotating rubber discs which transport them down to the opened furrow. Potatoes may be planted in much the same way.

Top: March in Norfolk, and it is time to sow the seed with an automatic seed drill. It drills the earth in parallel lines, drops in the seeds and covers them.

Above: A tractor-mounted broadcaster distributes fertiliser on a ryegrass ley.

Below: A large capacity sprayer in a field of winter barley. Occasionally this job is done from the air but usually a light tractor hauls the equipment.

Once the crop is in the ground, it must be maintained in good condition. This is a job for the sprayer, loaded with whatever pesticide, fungicide or selective herbicide is thought best to combat the latest scourge. Occasionally the job may be done from the air by a contractor; more commonly the equipment is hauled by a light tractor, travelling in the well-established wheel-tracks or 'tramlines' spaced to match the coverage of the spray-booms. The same system is used to provide a top-dressing of fertiliser, if required, by which time the farmer is already planning the forthcoming harvest.

GURNARDS: SPINY 'SINGERS'

Six species of gurnards occur in our coastal waters. All bear numerous sharp spines, and are remarkable for their unparalleled 'singing' ability.

Above: A grey gurnard on a sandy sea-bed off Orkney. Like other gurnards, it feeds mainly on bottom-living crustaceans and fishes.

Below: The bulky outline of a tub gurnard. There is an excellent view of the flat belly and massive head. The smaller fins are the pelvic fins. The larger pectoral fins each have three separated rays, which are clearly visible. Underwater lighting conditions have affected the colouring here.

Gurnards are very distinctive fishes, with large eyes set high up on the head and hard, bony plates, often with strong spines, covering the top and sides of the head. Some species even have tough bony plates running along the back and sides. Another characteristic feature is the pair of large fan-like pectoral fins, the lowest rays of which are separate from the main fin and form stout feelers beneath the throat. Gurnards skim slowly over the sea-bed probing for food with these long fin rays, which are well equipped with sensory cells.

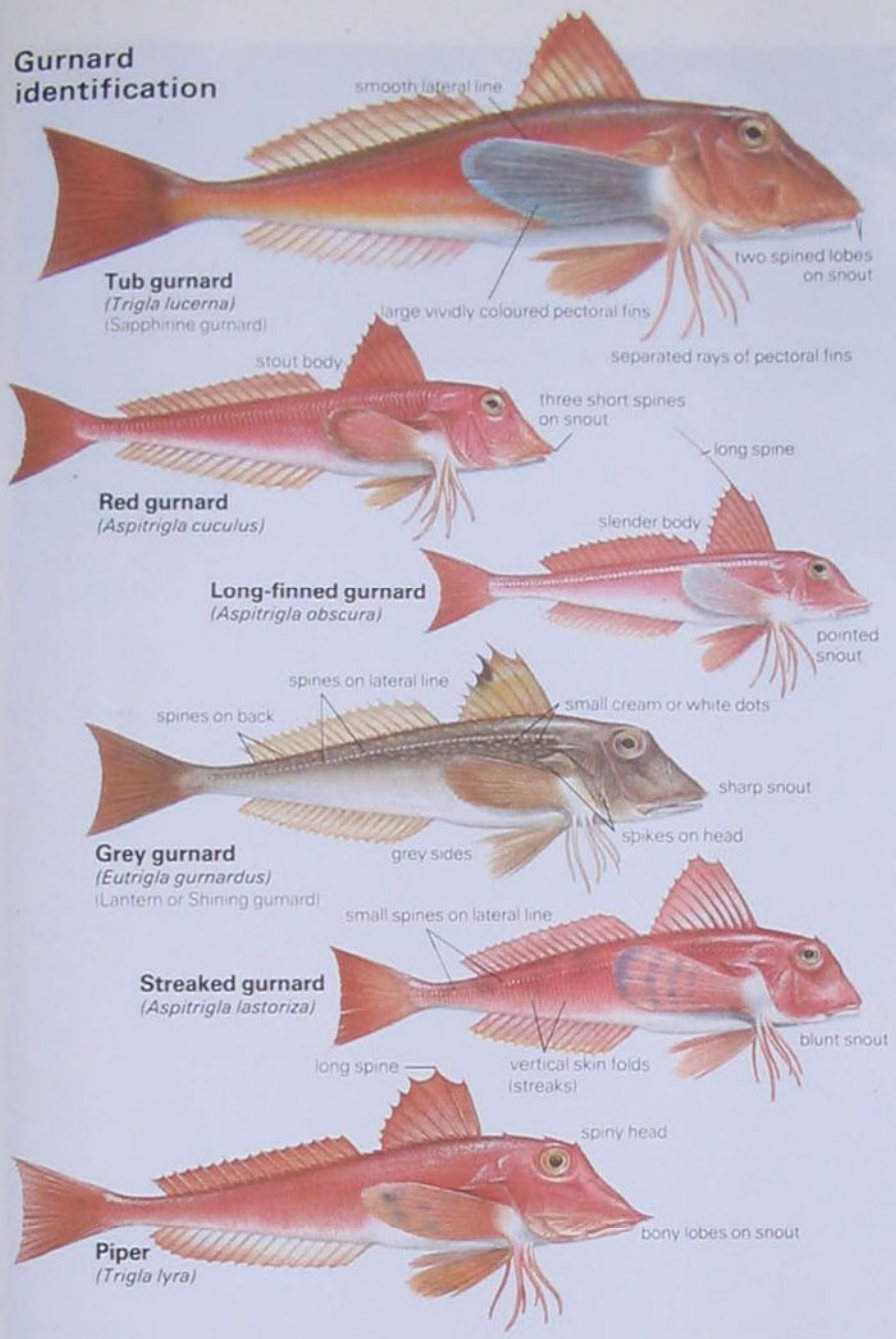
Two uncommon species Fortunately, the two least common of the gurnards in our waters, the long-finned gurnard and the piper, are the easiest to identify. The former has an exceptionally long spine in the first dorsal fin, its length being twice that of the other spines. The fin bearing this spine is itself noticeably elongated. The fish has a series of large and flexible scales along the length of its lateral line. Its colouring is reddish on the back and sides, shading to pinkish underneath; the lateral line is pearly pink in colour. The reflecting colour of the lateral line has earned it the alternative names of the lantern or shining gurnard.

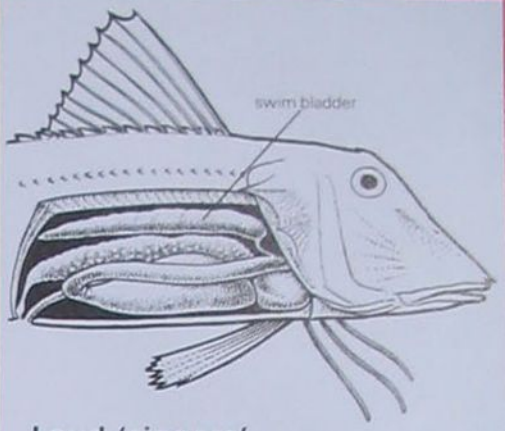
The piper, too, is bright red, the sides being rosy, while the belly is pinkish, but it is characterised by the two prominent bony lobes that juts out from its snout. Its head is remarkably spiny: one massive spine juts backwards over the pectoral fins. The back, too, carries numerous sharp spines, all pointing backwards. Sorting a trawl catch of pipers (almost all pipers are caught in trawls as they live mainly on the lower edge of the Continental shelf in depths of 300m/164 fathoms and deeper) can be a very painful activity on account of their spiky nature.

Tub gurnard This is the most widely distributed and abundant of all our gurnards; it is certainly the largest, and is possibly the most colourful. Its head is relatively large and its eyes are small (for a gurnard), and the spines on the head are only moderately large. Most significantly, the lateral line is smooth, and its pectoral fins are extremely large. Its back and upper sides vary from brownish to bright red, and its sides are mostly pink. The top surface of the pectoral fin is brilliantly coloured: it is peacock blue spotted with green, with red at the edge.

The adult tub gurnard lives in relatively shallow water (20m/11 fathoms or sometimes even deeper) but young ones live in much shallower water. It is usually most common on muddy or sandy bottoms, and feeds on a wide range of bottom-living animals, especially fishes and crustaceans–sand eels, small flatfishes, gobies and dragonets, swimming crabs and brown shrimps. It is the largest of our gurnards, growing to a length of 75cm (29½in) and a weight of 5.2kg (11½lb).

Red gurnard The size and predominantly red colouring of the tub gurnard cause anglers





Loud 'singers'

Gurnards are probably the noisiest fishes in our coastal waters. Each species has a large and very muscular swim bladder. This is vibrated by the muscles running along its sides to make what have been described as 'single, vibrant squawks or barks, growls and a series of rapid clucks'. Research into the sound made by fishes has shown that gurnards are noisiest when many of them are present, and also when there are other noise-making fishes close by. They are also especially noisy at dusk in the spawning season. These observations suggest that their sounds are produced to warn off competitors and possibly aggressors, and during the excitement of spawning when they must keep in close company with each other. Being bottom-living fishes which feed by stirring up the mud, it is a great advantage to them to keep in touch by sound rather than sight in what must be murky water. These sounds can be heard clearly in shallow water from a quietened boat, particularly at night when there are not so many other noises.

frequent puzzles. The true red gurnard is a much smaller fish, rarely growing to a length of even 40cm (16in) and a weight of 900g (2lb).

The red gurnard is a rather deep-bodied fish, with a moderate sized head and a large eye. Along its back lie two rows of sharp spines, one each side of the dorsal fin, but the lateral line is smooth although covered with large, expanded scales. As its name suggests, it is bright red, but the pectoral fins are pinkish with a dark edge, totally different from those of the tub. The red gurnard is most common on our southern and western coasts and lives on sand or gravel bottoms in depths of some 20m (11 fathoms).

Grey gurnard This is similar in size, growing to a length of 45cm (18in), but is very widely distributed all round the coasts of the British Isles. It tends to live off-shore in depths of 20-50m (11-27 fathoms), and is only locally caught in shallower water, and mostly in Scottish waters at that. It lives mainly on sandy bottoms, but is also found on mud and shell grounds.

Above: Six gurnard species are found in the coastal waters of Britain and Ireland. Three are relatively common: the tub gurnard, the grey gurnard and the red gurnard, their abundance and breadth of distribution round our coasts being in this order. The streaked gurnard has a somewhat local distribution, being moderately common in the western English Channel and to the south-west of Ireland, while the piper is relatively common in deep water to the west of the British Isles. The long-finned gurnard is rare; it has been found only in the western Channel, and then from very occasional captures. A seventh species, the armed gurnard, was reported last century.

The grey gurnard is dull coloured, brownish on the back with grey upper sides, fading to pale grey. The body is liberally spotted with small cream or white dots, and there is a rounded black spot on the edge of the first dorsal fin. It has sharp spines along the back as well as on the head.

Streaked gurnard The sixth, and one of the less common gurnards (of the species described here, only the long-finned and the piper are rarer), is the streaked gurnard. This is a dumpy, heavy-bodied fish with a blunt snout and small, deep head. A small species—not often exceeding 36cm (14in) in length—its most obvious feature, which gives it its name, is the series of skin folds that run vertically along the length of the body, originating from the lateral line. It is a dull red in colour.

It is rare in British waters except in the western English Channel, although it is not abundant there. It lives in moderately deep water of 40m (22 fathoms) and sometimes even deeper than this.

HEATHERY EXMOOR

Exmoor National Park, on the borders of Somerset and Devon, is a beautiful compact area of hilly country with a very definite upland character, even though it has no mountains.

Above: A view of Exmoor, near Five Barrows Cross.

Right: The insect life of Exmoor is rather sparse but interesting: a number of northern species find their southernmost locality here, and in some cases there exists both the northern race (persisting as a 'glacial' relic) and the southern race (occurring as a later colonizer). For example, the typical oak eggar moth occurs in the lowlands, while the northern eggar appears on the moors.

Oak eggar ♀

Northern eggar ♀

Collectively this National Park includes the whole of Exmoor, with the old Royal Forest, together with much of the Brendon Hills which lie to the east of the main mass. Exmoor is probably best described as a dissected plateau, with large areas of undulating moorland at between 365m and 455m (1200-1500ft) in height, rising to 520m (1708ft) at Dunkery Beacon, and deep, steep-sided valleys carrying the rivers north to the Bristol Channel or south to the English Channel.

The contrast between the high, treeless moorland and the deep, usually wooded valleys is one of the chief attractions of Exmoor. In addition, though, it has a feature which is unrivalled elsewhere in England–a 46km (29 mile) coast stretching from Minehead to Combe Martin and consisting of an almost unbroken line of hog's back cliffs, rising in places to over 365m (1200ft).

The high moorlands The high plateau and hills support a mixture of heather-dominated moorland or *Molinia* grass moorland, much of which has been converted, over the last 150 years, to rather poor pasture; the process is still continuing, giving rise to considerable controversy. The heather moorland consists mainly of ling, with smaller amounts of gorse of two species–common gorse and western gorse. The dwarf western gorse grows to the same height as the heather, and many of the coastal hills support a patchwork of gorse and heather–beautiful to look at in summer but almost impossible to walk through.

One high remote area of the moor is known evocatively as 'The Chains'; it is a wild, lonely area with a rainfall of over 1980mm (80in), and consists of extensive stretches of bog and some 60ha (150 acres) of deer sedge–the largest such area of deer sedge in southern England. It is the source of most of the moor's rivers, including the Exe and the Barle.

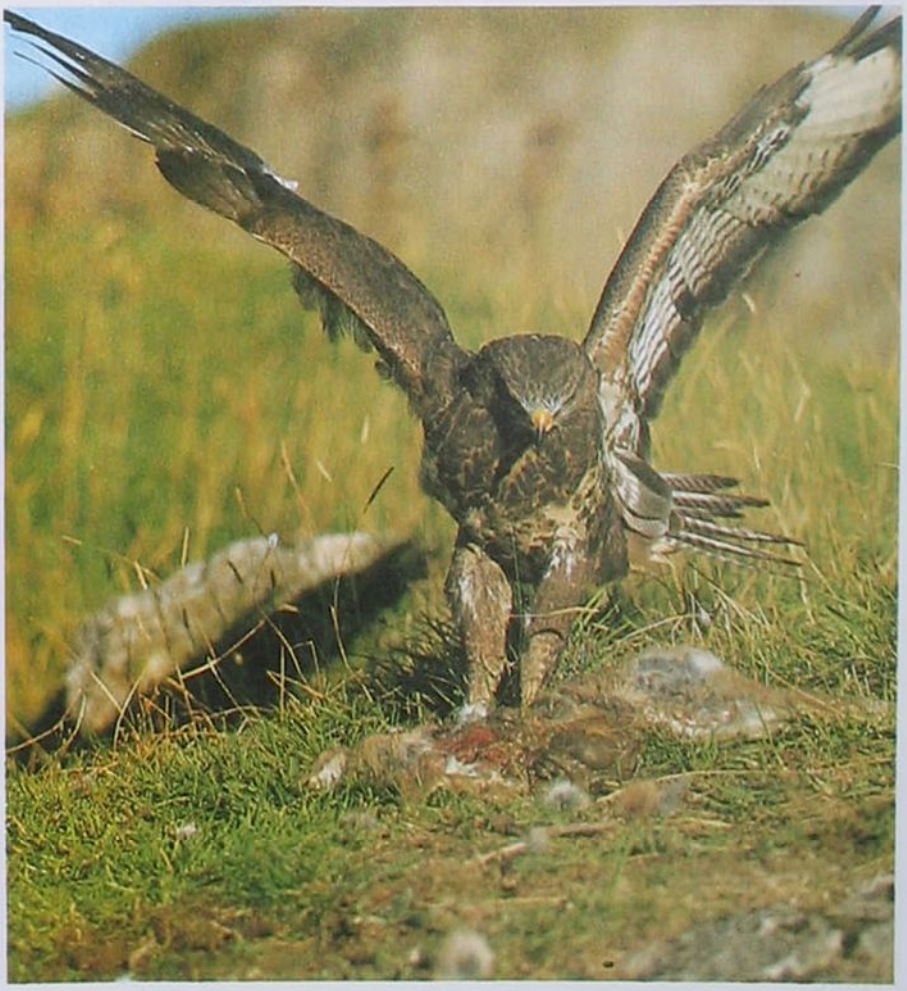
Oak woodlands and river valleys Where the moorland drops steeply into the valleys, or towards the coast, the vegetation frequently changes dramatically. Most of these steeper slopes are clothed with beautiful ancient oak woodlands, although in places they have been 'reclaimed' or planted with conifers. The abrupt ending of the woodlands at 305-365m (1000-1200ft) is partly a natural tree-line, but it is also caused by heavy grazing and burning on the high moors.

The woods consist mainly of oaks–sessile oak towards the top and common oak lower down, and hybrids between the two–although in places there are stands of wych elm, ash, birch and rowan, with other trees such as small-leaved lime, maple and some rare whitebeams occurring very sparingly. The soils are almost all acid, deriving from the parent sandstones and slates, which limits the range of species that can do well.

The rivers that flow down the valleys are beautiful clear, clean streams full of small brown trout. There are virtually no sources of pollution here, especially in the northern

Right: Pale butterwort occurs in several bogs or hillside 'flushes' on Exmoor. It flowers from June to October. Unfortunately for wildlife on Exmoor, there is conflict between agriculture, conservation and amenity use. Much of the character of Exmoor depends on its wildness and its semi-natural vegetation of moorland and woodland. The continuing enclosure and ploughing of heather moorland to produce rather poor quality pasture–in a National Park and area of great scientific value–is seen by most people as a foolish use of our limited resources. This 'reclamation' continues in the absence of adequate powers and financial resources to protect it, though new legislation and the public ownership of increasing areas give some hope for the future.

Below: A buzzard with its prey–a rabbit. Buzzards can be seen almost everywhere on Exmoor.



rivers which arise on the high moor and flow straight into the sea a few miles away. The rivers therefore support caddisflies, mayflies, stoneflies and dragonflies–just as an upland river should. They are also notable spawning grounds for salmon and trout, and there are many small falls where salmon can be watched leaping their way up to the gravelly redds to spawn.

Above: There is a native population of some 600 red deer on Exmoor.

Below: A dipper at the edge of a swift stream. Often seen along Exmoor's rivers, this bird nests under bridges or overhanging rocks.

Coastal riches In many ways the coast is the most exciting of the habitats that make up Exmoor. It is clothed for part of its length by beautiful woodland that is slightly more species-rich than the inland woods because of the eroding, less acidic soils. The more open areas support heather moorland, usually with bell-heather rather than ling because of the better drainage, and often with banks of rhododendron or clumps of gorse. The cliffs themselves, mostly of red sandstone, are broken and eroded and make poor seabird breeding sites, with just a few colonies in one or two places along the coast.

Here and there the coast is broken by a valley, the largest and most interesting of which is the vale of Porlock. Porlock used to be a port but is now a mile or so inland and parts of the former sea-bed are now used to grow arable crops. The outer margin of the vale is formed by an enormous coarse shingle bank, virtually devoid of life; just inland, however, lies an area of tiny saltmarshes, reed-beds and lakes, and old pasture. Sadly, the area of interesting habitat has contracted steadily over the years as agricultural activities have eaten into it, but it is still a fine bird haunt and the home of a number of coastal plants, though many less than there used to be. Hurlestone Point, to the east, is a good site for coastal lichens.

Flora and fauna The animal and plant life of Exmoor is an intriguing mixture of upland and lowland. It is not excessively rich in rare species–for example, there is no limestone of any significance where rare plants might occur–but there are many species growing here that barely occur elsewhere in southern England, and a few specialities that are virtually confined to Exmoor.

Among the mammals, two are particularly notable. First–and probably most famous–is the red deer. An indigenous population of about 600 animals occurs on the moor, separated into a number of more or less distinct herds. They behave here as woodland animals–their traditional haunt–unlike the Scottish red deer which have had to move out into the open. The other well known mammal is the Exmoor pony which, though by no means abundant, is probably the most interesting of our 'wild' ponies. Otters, too, can be found but are difficult to spot.

The bird life is sparse, except in the combes (valleys), but fascinating. Merlins still nest on the high moorlands, though they are now very rare. Black grouse are native but rare and declining, while red grouse were introduced many years ago and have persisted here and there. Buzzards are everywhere, and ravens are by no means uncommon, their deep 'honking' call often being heard on fine spring and summer days, while the clear call of ring ouzels can be heard in some of the high rocky valleys. In the deep wooded valleys, such as Horner Combe, or near Tarr Steps, the air is

Above: Heather moor under Dunkery Beacon. This beacon is the highest point on Exmoor, reaching 520m (1708ft), but it is rounded and smooth rather than craggy, and is dissected by myriads of small streams. In late summer Dunkery Beacon is purple with the blooms of heather.

Below: This map shows the extent of the National Park, with some of the main features of interest.

alive with birdsong in spring and summer. The gnarled old trees provide nest sites for many less common birds, such as redstart, pied flycatcher, stock dove and wood warbler, as well as for many of the more usual woodland birds.

The plant life is dominated by the widespread common species that are tolerant of acid conditions; they include heather, gorse, flying bent, cottongrass and so on, but here and there, usually in small numbers, there are many plants of interest. The flora in general has elements of northern, southern and western species. Pale butterwort can be found in several boggy areas, while Irish spurge, another western species, occurs here in one of its few mainland localities. Crowberry, lesser twayblade, Welsh poppy, stag's-horn clubmoss and the parsley fern are all examples of northern species with small populations on Exmoor, though the clubmoss has been declining for many years and the parsley fern appears to have succumbed to the 1976 drought–such events are a common problem to plants at the edge of their range. Other species of interest include bastard balm, now confined to one or two localities, and wood vetch, which is abundant in places along the coast. There is also a rare whitebeam growing along the north coast and nowhere else in the world, and the attractive rock stonecrop, too, is common along parts of the coast.

PIPITS OF MEADOWS AND ROCKY COASTS

The meadow pipit is the most conspicuous small bird of moorland, and is often seen in upland meadows, especially when performing its high-flying display in spring. The rock pipit looks similar, but its habitat is the rocky coastline.

As every experienced hill-walker knows, the most numerous bird at altitudes of 500-1000m (1500-3000ft) is almost always the meadow pipit. In spring and summer, the moors and rough, sheep-grazed grassland in Wales, the Pennines and Scotland seem alive with these small, streaked birds. And well they might, for Britain and Ireland can boast a population of some three million pairs of meadow pipits, at densities which sometimes exceed 50 pairs per square kilometre.

An insect hunter At 14.5cm (5¾in) in length, the meadow pipit is of similar size and build to the dunnock. As would be expected of an active, ground-feeding insectivore, it has long legs and toes and a finely pointed bill. The hind toe carries a very long claw.

The majority of meadow pipits live in open upland habitats, but many can be found in more accessible places. Heaths, sand-dunes and saltmarshes all provide suitable feeding and nesting sites, and even intensively cultivated farmland may hold a few pairs if one or two grassy banks or field corners remain undisturbed. The only large areas without meadow pipits are in central and south-east England, and comparison with geological maps suggests that one reason for this might be the presence of heavy clay soils in these regions. The soil itself is unlikely to be an important factor, but the invertebrate fauna associated with it may not be suitable for the birds.

As autumn approaches, and especially when snow returns to the mountains, many meadow pipits are forced to congregate in valleys and lowland areas. In winter, loose flocks are found in almost any open habitat, mixing freely with finches, buntings and skylarks.

Recognition features The meadow pipit can be distinguished from similar birds by its combination of streaked plumage, white outer tail feathers, fine bill and a running gait as opposed to a hopping one. The plumage provides excellent camouflage, the head, back, wings and tail being generally brownish in colour, often with a greenish tinge. The underparts are creamy white, boldly marked to a varying extent with brown or blackish streaks, which also extend over the shoulders on to the back. Usually, the throat, belly and undertail coverts are pale brown. Finally, many of the wing feathers have pale edges and at times these result in two narrow wing bars.

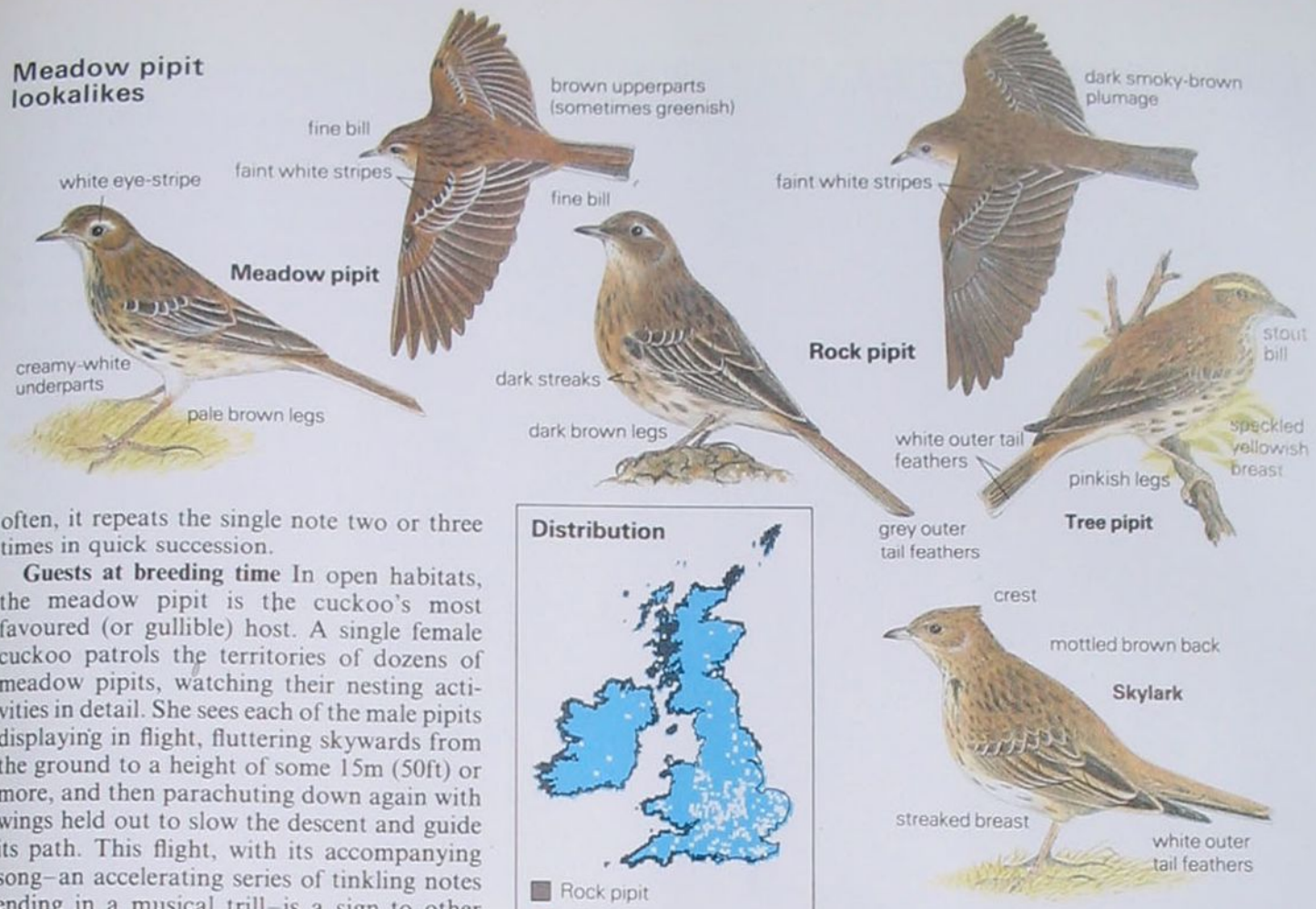
Flight and call Apart from its general appearance, the other main identification features of the meadow pipit are its way of flying and its flight call. These are well worth memorising, since it often flies off without allowing an observer to approach closely. Notice how jerky and hesitant the bird's flight is, with very short bursts of flapping. Then listen to the call: a single, very high-pitched and distinctive 'sweep'. Only rarely will the meadow pipit take flight without calling; more

Above: A meadow pipit seen against the open sky. In its exposed habitat, the species is particularly prone to attack by raptors.

Meadow pipit (*Anthus pratensis*). Present all year, some birds wintering overseas. Sexes alike. Length 14.5cm (5¾in).

Rock pipit (*A. spinoletta*). Resident. Sexes alike. Length 16.5cm (6½in).

Right: A rock pipit chick, at fledging age.



often, it repeats the single note two or three times in quick succession.

Guests at breeding time In open habitats, the meadow pipit is the cuckoo's most favoured (or gullible) host. A single female cuckoo patrols the territories of dozens of meadow pipits, watching their nesting activities in detail. She sees each of the male pipits displaying in flight, fluttering skywards from the ground to a height of some 15m (50ft) or more, and then parachuting down again with wings held out to slow the descent and guide its path. This flight, with its accompanying song–an accelerating series of tinkling notes ending in a musical trill–is a sign to other meadow pipits that 'this patch of land is mine', but it must also give the cuckoo a good idea of where the pipits are likely to nest.

The nest is built by both sexes on the ground among tussocky grass, heather or other low vegetation. Protection from the wind and rain are essential, and often the chosen site is in a sheltered hollow, particularly where tangled grass forms a roof as well as walls on all sides of the nest. Dry grass forms the main structure, while finer grasses and some hair make a warm lining.

The eggs are rather variable in colour, but are most often brown or grey with dark brown speckles. The female lays one egg daily, usually four or five in total, but sometimes up to seven. It is during these few vital days that the female cuckoo flies down, picks up one of the eggs in her bill and lays her own in its place. Even though the pipits may watch this event, they fail to realise its significance; the cuckoo is chased off and life apparently returns to normal while the female pipit incubates the eggs.

On average, meadow pipits' eggs take 13½ days to hatch. The young would normally be fed in the nest by both parents for another two weeks until they fly. However, cuckoos hatch in only 12½ days. Thus, in a meadow pipit's nest, a cuckoo chick has a full day to complete the well-known but nonetheless fascinating process of ejecting the other eggs from the nest. Subsequently, the young cuckoo's begging is so persistent that the pipits feed it for three weeks in the nest, and then continue

Above: A meadow pipit's foot has a long hind claw.

Right: The nest and eggs of a meadow pipit in long, tangled grass.

Below: A rock pipit finds food among the boulders.

Above: A meadow pipit feeds its brood. The diet of invertebrate animals normally given to young pipits is ideal for young cuckoos as well.

Below: A meadow pipit foraging. Like the closely related wagtails, pipits walk or run rather than hop.

after it becomes mobile, until it becomes fully independent.

A partial migrant Meadow pipits nesting in the northern part of their range migrate south in winter. This includes those in north-west Europe and Ireland, and some of the British birds. Some remain here in winter, but others fly as far as western France, Spain, Portugal and even north Africa. Most return to their breeding territories as soon as the weather permits, and British meadow pipits lay their first clutches in April, a full month before the cuckoos arrive. Of the second clutches, as many as one in ten may be parasitised by cuckoos.

The rock pipit This is a slightly larger species than the meadow pipit (16.5cm/6½in in length) with darker, somewhat smoky coloured plumage. The streaks on the breast and back are less noticeable than those of the meadow pipit, and in addition the outer tail feathers are grey (not white), and the legs are dark brown or black (not pale brown).

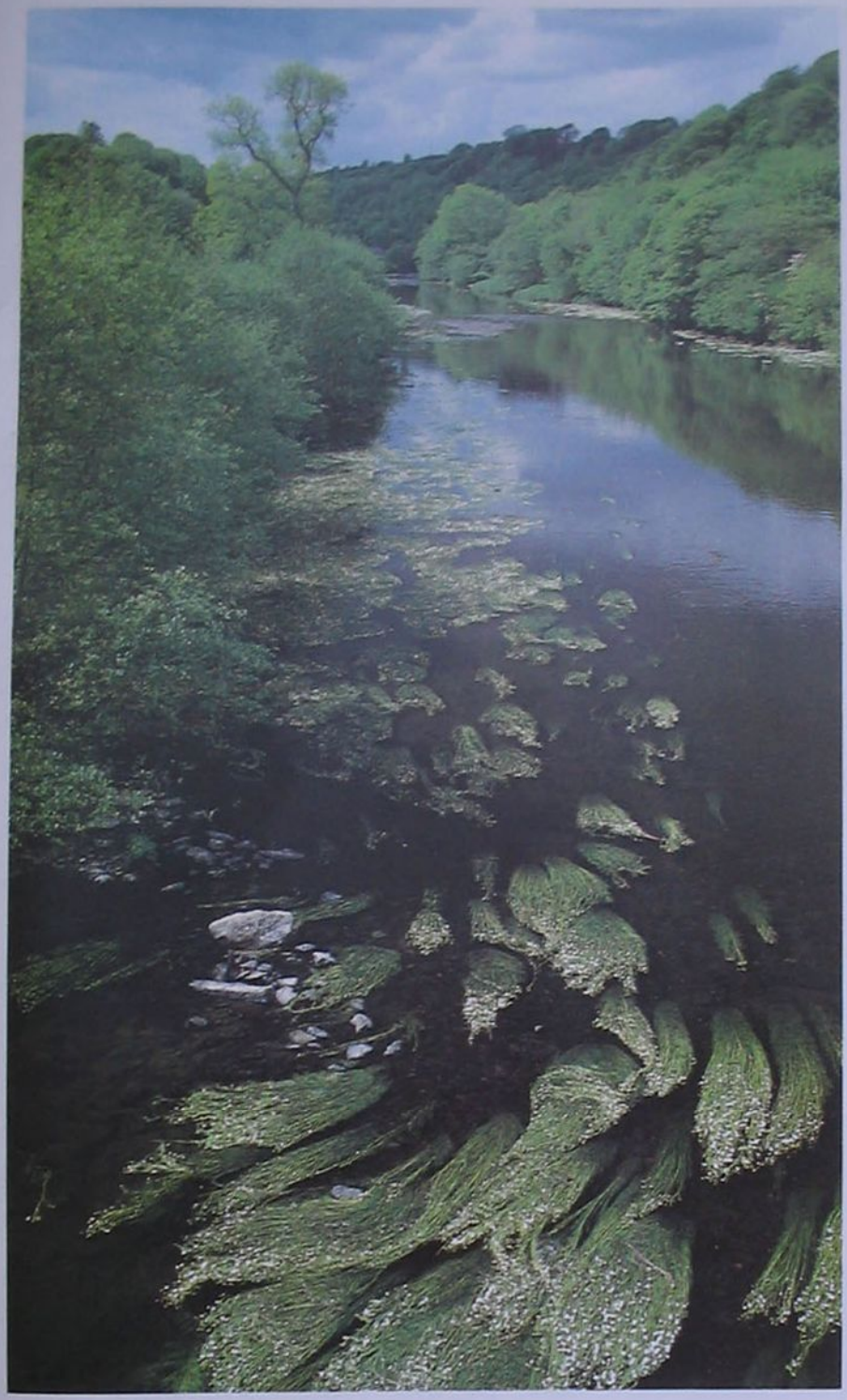
In Britain and Ireland, the rock pipit breeds only on rocky coasts and islands. Since such habitats rarely freeze, this species is less affected by harsh winters than the meadow pipit, and many pairs remain in the same territories all year round. Only a few wander to sandy beaches or estuaries.

Rock pipits spend much of their time creeping over seaweed-covered boulders and along high-tide lines, especially in winter. They can be very difficult to see as they search for the insect larvae and crustaceans which abound in these places. Many rock pipits seem to survive almost solely on a diet of tiny periwinkles, eating more than their own weight of food each day. In summer, they forage more often among grass close to the shore, and therefore may be seen alongside meadow pipits if these are present.

Some experience is needed to distinguish the rather less squeaky call note of the rock pipit from that of the meadow pipit. The rock pipit's song flight, too, is only slightly different. Apart from the difference in habitat and a slightly longer fledging period of about 16 days, the nesting details, too, are similar, including the parasitic behaviour of the cuckoo.

Winter visiting race Geographically, and taxonomically, the rock pipit is a curious bird, for in the mountains of central and southern Europe lives a bird which, although it is called the water pipit, is considered to be the same species as the rock pipit. They are certainly distinguishable, since the water pipit has white outer tail feathers, a white eye stripe and, at least in summer, a much paler overall appearance, but their many similarities suggest that they are merely two separately evolving populations of a single ancestral species. These probably divided geographically many centuries ago, perhaps during the last Ice Age.

Water pipits are seen in England and Wales only in winter–between October and April–and usually only in ones and twos. Freshwater habitats seem to be preferred (as in their breeding range), with most records coming from marshes, pools, reservoirs, sewage farms and watercress beds. Other races of rock pipits are found in Asia and in North America. It is thought likely that these localised races are the result of the birds' sedentary way of life, without the mixing effect of migration.



Above: Pond water-crowfoot in flower on the River Bandon at Inishannon, Ireland.

Left: Water-crowfoots come into flower some time between May and September, the exact time depending on the species. The flowers have the typical structure of a buttercup: a central mass of stigmas surrounded by yellow anthers and a ring of petals, which are white with yellow bases. The species shown here is the river water-crowfoot.

WATER CROWFOOTS

With their summer blaze of flowers, water-crowfoots are one of the most characteristic plant groups of our rivers, yet telling the species apart can tax even the expert.

Water-crowfoots, or water buttercups as they are sometimes known (they belong to the same genus, *Ranunculus*, as the buttercups), are particularly associated with fast-flowing, shallow rivers. However, different species show clear preferences for different habitats, and they also have distinct geographical distributions.

Yet, despite these variations between the species, water-crowfoots are notoriously difficult to identify. This is mainly because flowing water is a very changeable medium (botanists call it a 'plastic' medium) and the depth of water, the speed at which it flows and its chemical composition can all vary remarkably from one river to another and even within the same river. Such variations, of course, produce a response in the form of the plant, for example in the shape and size of its leaves. A single species of water-crowfoot may, therefore, look totally different depending on whether it is growing in shallow or deep water, in a sheltered pond or exposed to the full force of a river in spate.

Stream species Two species are characteristic of shallow streams rather than rivers, and are known commonly as crowfoots, not water-crowfoots. These are the ivy-leaved crowfoot (*R. hederaceus*) and the round-leaved crowfoot (*R. omiophyllus*). Both are also found in temporary pools and in soft mud at the margins of rivers. Neither develops the finely dissected, submerged leaves of the river species. Instead, the leaves are shaped roughly as indicated by the plants' common names. In flower, the ivy-leaved crowfoot has petals and sepals of the same length, while the sepals of the round-leaved crowfoot are less than half the length of the petals and are also bent backwards down the stalk.

In the wild, both plants are usually annuals and there is no record of their interbreeding, unlike the situation between several species of water-crowfoots. The ivy-leaved species is far more widespread, being found throughout the British Isles. The round-leaved crowfoot is absent from central and eastern England, central and northern Scotland and central, western and the north of Ireland. Yet, despite this, it is the more common species of the two

in streams. It is found in small streams at high altitudes, where it prefers water that is acidic and poor in nutrients.

River species The remaining species are all found in rivers and are known commonly as water-crowfoots. There are seven species but you are very unlikely to see more than three species in the same river system because they all have special requirements.

The seven species can be divided into two groups. The first consists of the river, brook, thread-leaved and fan-leaved water-crowfoots. They all develop finely dissected, submerged leaves, but do not bear floating leaves. The remaining three species–the common, pond and stream water-crowfoots can all bear broad floating leaves as well as the submerged dissected kind. However, the floating leaves may not always be present, in which case identification may become very difficult.

Deep rivers The most characteristic water-crowfoot of deep rivers is the fan-leaved water-crowfoot (*R. circinatus*), so called because its delicately dissected leaves are rigid enough to maintain a fan shape under water. This species is typical of Fenland rivers and those flowing over clay soils, and it is also at home in canals, provided the water has a high alkalinity.

The river water-crowfoot (*R. fluitans*) is another species rarely found in small streams, preferring instead deep water that will remain at least 30cm (1ft) deep throughout the year, except in the driest conditions. This species can grow to a great length, single plants 2m (6ft) wide and 5m (16ft) long being not uncommon. It roots into the river-bed only at one point upstream of the plant, the remainder of the plant whirling downstream in the current. For this reason it requires a very

Above: A mass of flowering common water-crowfoot in a Surrey pond. Too luxuriant a growth can choke the pond, though it also indicates that the water is clean–water-crowfoots cannot survive much pollution.

Below: Common water-crowfoot showing its narrow submerged leaves and broad floating leaves.

stable bed to root into.

The river water-crowfoot has a curious distribution. It is common in large English rivers as far west as the Welsh border, and it is occasionally seen in large, stable rivers in Scotland. However, in south-west England and the Lake District it is very rare, and it is not found in any of the Welsh rivers flowing west into the Irish Sea. Yet it does occur as an isolated community in the River Ffraw in Anglesey, and it also occurs in one Irish river, the Five Mile River in Antrim, though it is absent from the rest of Ireland.

The third water-crowfoot of deep rivers, the stream water-crowfoot (*R. penicillatus*), has a complementary distribution to that of the river water-crowfoot, being found in many Irish and Welsh rivers. Although these two species have quite separate distribution patterns in the British Isles, on the Continent they overlap to a great extent. The reason for their British distributions is probably that the river water-crowfoot is a much slower colonizer so, after the last Ice Age, the stream water-crowfoot travelled westwards faster and established itself in Ireland and Wales.

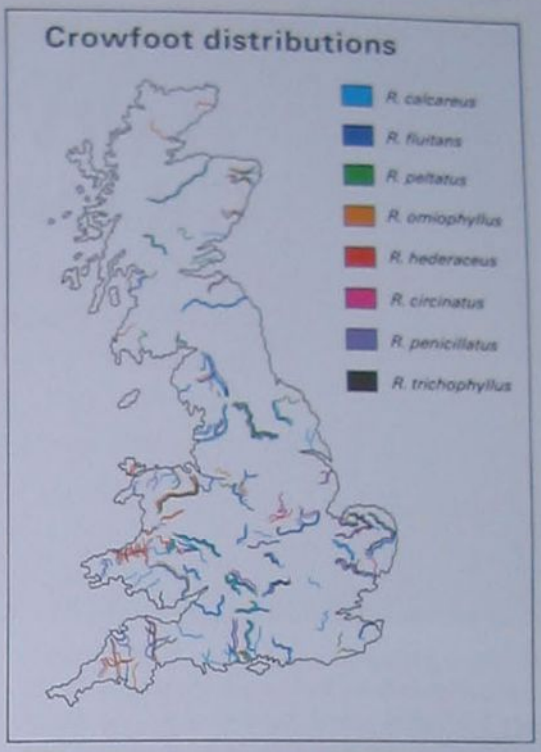
The two species look very similar to each other in their vegetative (ie, non-flowering) state, the stream water-crowfoot being almost as large. In flower, however, the stream species nearly always produces large semi-circular floating leaves, which serve to distinguish it from the river species.

Plants of shallow rivers In chalk rivers, the characteristic member of this group of plants is the brook water-crowfoot (*R. calcareus*), a species seen at its best in the shallow chalk streams of Hampshire, with their crystal-clear water and gravel bottoms. The brook water-crowfoot forms roots at its nodes, which give it a greater ability than the river water-crowfoot to grow on stony, unstable riverbeds. The rooting nodes also allow the plant to colonize sites downstream.

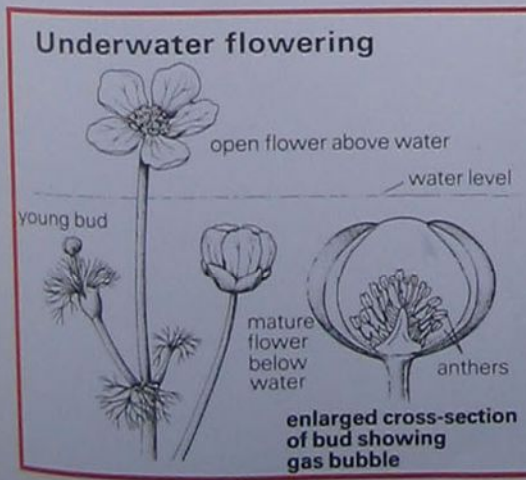
The three species in this group most difficult to tell apart outside the flowering season are the thread-leaved, common and pond water-crowfoots. Fortunately, however, they are not often found growing in the same place. In shallow, nutrient-rich streams feeding into large rivers, the thread-leaved species (*R. trichopyllus*) is the most likely one to be encountered. The pond water-crowfoot (*R. peltatus*) is most typical of the upper reaches of chalk streams, and the common water-crowfoot (*R. aquatilis*) is found in rivers that are poor in nutrients or very alkaline.

The thread-leaved water-crowfoot tends to have the smallest flowers (the petals are less than 6mm long) and the pond species the largest (petals more than 10mm long). But the only sure way to distinguish them is to look at the nectar-producing glands at the base of each petal. These are circular on the common species, pear-shaped on the pond and shaped like a half-moon on the thread-leaved.

Right: The British distributions of some of our native water-crowfoots. Most occupy quite distinct geographical areas so that one species is not often seen with another along the same stretch of water. The fan-leaved water-crowfoot (*R. circinatus*), for example, is confined to the Fenlands and rivers flowing over clay soils, while the stream water-crowfoot (*R. penicillatus*) is found only in the far west of the British mainland.



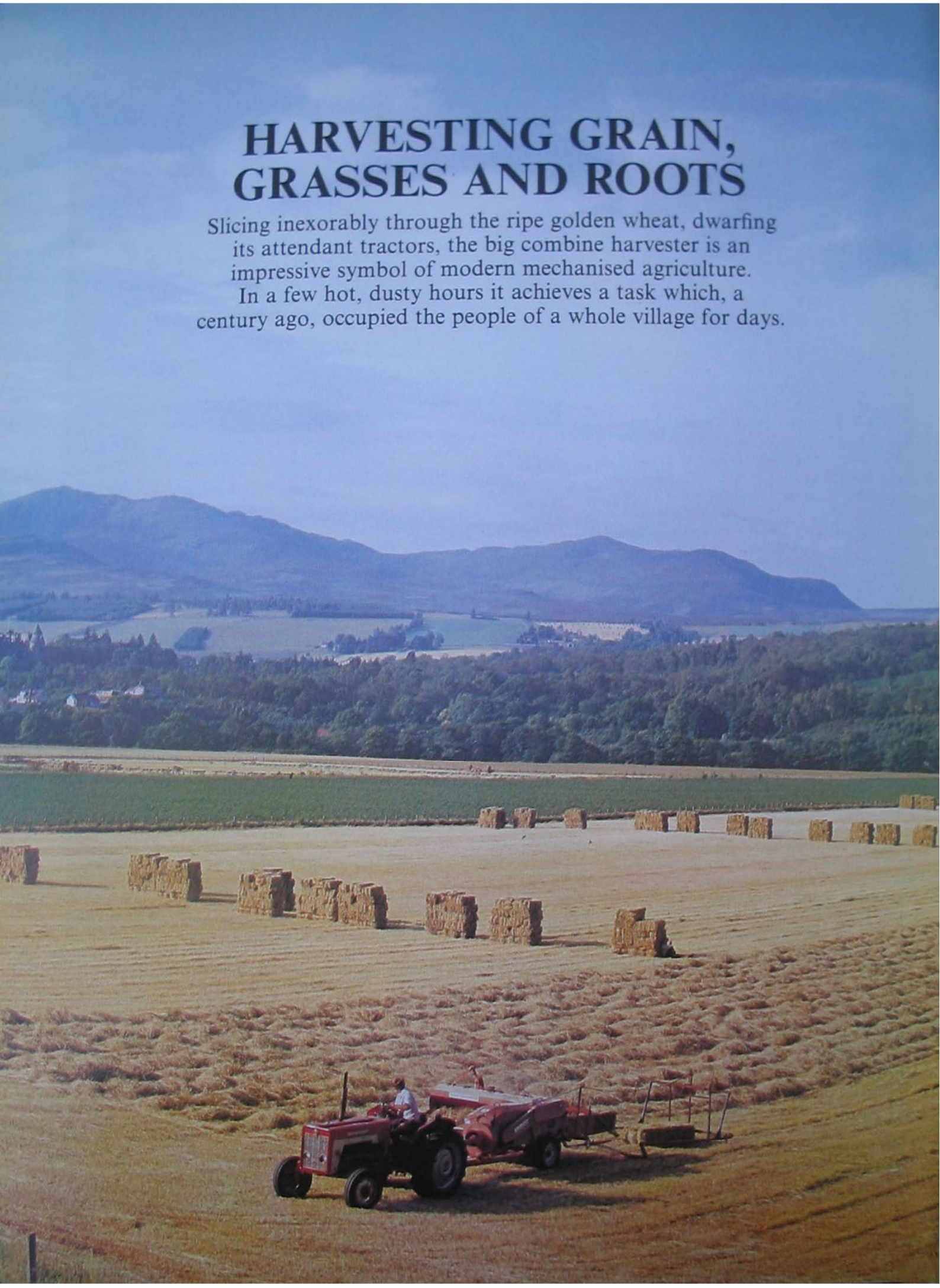
Below: The ivy-leaved crowfoot is one of two species found in shallow streams and temporary pools. The other–the round-leaved crowfoot–is far less widespread.



Water-crowfoots in deep rivers are unlikely to flower if the water level is too high for the plant to break through to the air. A few species, notably the fan-leaved water-crowfoot, overcome this problem by flowering under water, forming a gas bubble within the partly opened bud so that pollination can occur inside a dry mini-environment.

HARVESTING GRAIN, GRASSES AND ROOTS

Slicing inexorably through the ripe golden wheat, dwarfing its attendant tractors, the big combine harvester is an impressive symbol of modern mechanised agriculture. In a few hot, dusty hours it achieves a task which, a century ago, occupied the people of a whole village for days.



The advantage to the farmer of the big combine harvester is immense. The harvest can be brought in rapidly and at short notice when conditions are right, and with the crop safely off the field and under cover, autumn cultivations can begin without delay, enabling winter cereals to be established before the weather breaks.

The speed at which such machinery works is one of its principal attractions. It is bought, however, at the expense of flexibility. Twenty men may harvest anything, be it grain, roots, vegetables or even mushrooms. The 19th century farmer was free to grow any crop which the market suggested, provided the land was suitable. In contrast, the mechanised farmer of today is constrained by the limitations of his equipment. Each harvesting machine is designed to gather a particular type of crop with speed, precision and economy, a specification which in many cases demands great mechanical complexity. In consequence the harvester is often the most expensive machine on the farm, and the farmer is well advised to tailor his cropping policy to suit it. To do otherwise means incurring the expense of a contractor, or even manual labour, while a major capital investment lies idle.

The combine harvester For many arable farmers the basis of cropping strategy is the combine harvester. The name refers to its function as a combined harvesting and threshing machine, designed for use on crops grown for their ripe seeds or grain. Before its general adoption in the 1940s and 1950s, these crops (mainly cereals) were cut when half-ripe with a reaper-binder and stacked in the field to ripen. Cut early in this way the crop was less fragile, and less likely to shatter and spill grain back on the field. After a week or so in the sheaf, it could be fed into a threshing machine, which employed a toothed revolving drum to break up the seed-head, and a series of sieves and fans to separate the grain from the chaff. The modern combine harvester incorporates just such a machine, mounted on the back of what is basically a reversed tractor fitted with a cutter bar (see diagram).

Above: A combine harvester at work in a wheat field in Suffolk. Today just two or three men are employed, with the aid of a machine which does the job of an army of reapers, rakers and threshers.

Opposite page: Perthshire in July when the hay is being baled.

Below: Before combine harvesters, crops were cut when half-ripe. The seed head was retained intact on a long stem, enabling the crop to be bound into sheaves and stacked in the field to ripen.

The grain must be ripe for effective threshing, so the old technique of cutting early is out of the question. Nonetheless, most farmers try to bring in the crop while the moisture content is still fairly high to avoid knocking the grain out of the ear on impact. The result is a heap of damp grain which has to be put through an electric drier before it is fit to store.

British arable farming is dominated by cereals, principally barley and wheat, and nearly every farm uses a combine harvester. It is possible with the aid of modern pesticides to grow cereals continuously on the same land, but in practice few farmers do so. Instead they employ variations on the old idea of crop rotation. For a cereals specialist this means giving the soil a rest by planting a crop with different requirements once every few years, which can be harvested with the combine. This is known as a combinable break crop. It may be any seed which will withstand the threshing process, from mustard or oilseed rape to dry, ripe peas or beans: the combine harvester can deal with them all, if properly adjusted. In this way the management of whole agricultural landscapes may be dictated by one particular havesting machine.

Forage crops The other main crop category found on the average farm is the forage crop. This is grown for its foliage which is fed, fresh or preserved, to livestock.

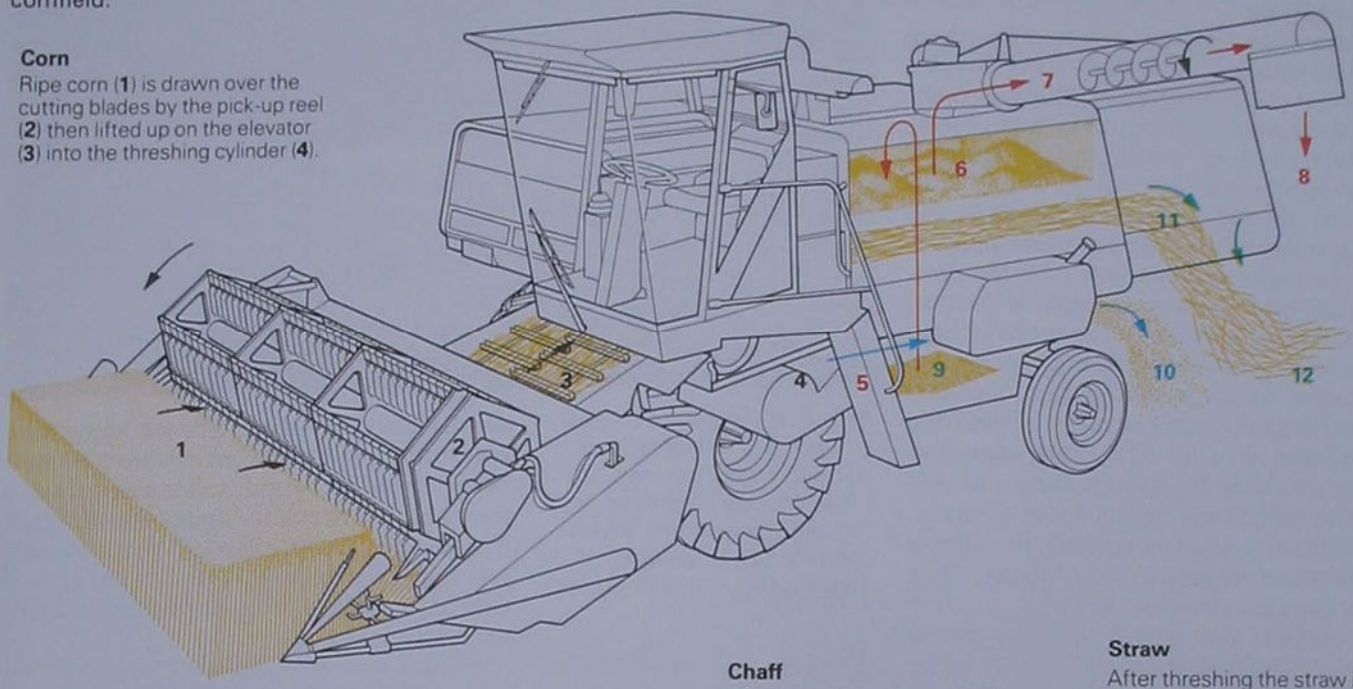
The stockman enjoys an advantage over the purely arable farmer in that his animals may do their own harvesting. Indeed, it is possible to do without harvesting machinery of any kind and rely on the animals' own feet to take them from one crop to the next. If that crop is merely permanent grass. as is the case on some

How a combine harvester works

The combine harvester is a travelling factory, cutting, threshing and separating the grain, straw and chaff as it moves steadily through the cornfield.

Corn
Ripe corn (**1**) is drawn over the cutting blades by the pick-up reel (**2**) then lifted up on the elevator (**3**) into the threshing cylinder (**4**).

Grain
After threshing the grain is sieved (**5**) and lifted into the storage tank (**6**). From here it is unloaded by a spiral auger (**7**) and collected in a trailer (**8**).



Chaff
After threshing the chaff is blown out of the sieves by a fan (**9**) and is then deposited on the ground (**10**).

Straw
After threshing the straw is expelled from the combine (**11**) and on to the ground ready for bailing or burning (**12**).

hill farms, cultivation equipment may be dispensed with altogether; this is known as 'dog and stick farming'. In practice farmers need supplementary rations for the winter so the production (or purchase) of harvestable crops is imperative for all but the hardiest of stock. Cereals and pulses are important, but the bulk of the ration is made up of forage crops.

Of these the most important is grass, traditionally harvested as hay. Haymaking requires simple but specialised equipment, a fair amount of time and energy, and luck with the weather. Many farmers have abandoned it in favour of more dependable alternatives, but as part of the dairy cow's diet its value is undeniable: the fibre stimulates the production of butterfat and improves the quality of the milk. Thus many dairymen, while not relying on hay, continue to make it.

The first step is to cut the long grass while it is still green and succulent. At this stage the moisture content is high; the quicker the grass dries the better, so a mower-conditioner is employed to break and bruise the stems and leaves as they are cut, enabling moisture to escape more rapidly. Driven from the power-take-off shaft of the tractor, the mower-conditioner leaves the cut grass in a series of long heaps or swathes, ready for the next operation. This is accomplished by the hay tedder, a pair of contra-rotating rakes mounted on the tractor which fluff up the grass to dry in the sun. This rough treatment is repeated until the increasing fragility of the grass dictates a switch to the swathe turner, a set of rimless wire wheels driven by ground contact which roll the swathe over on to warm, dry land until the haymaking is complete.

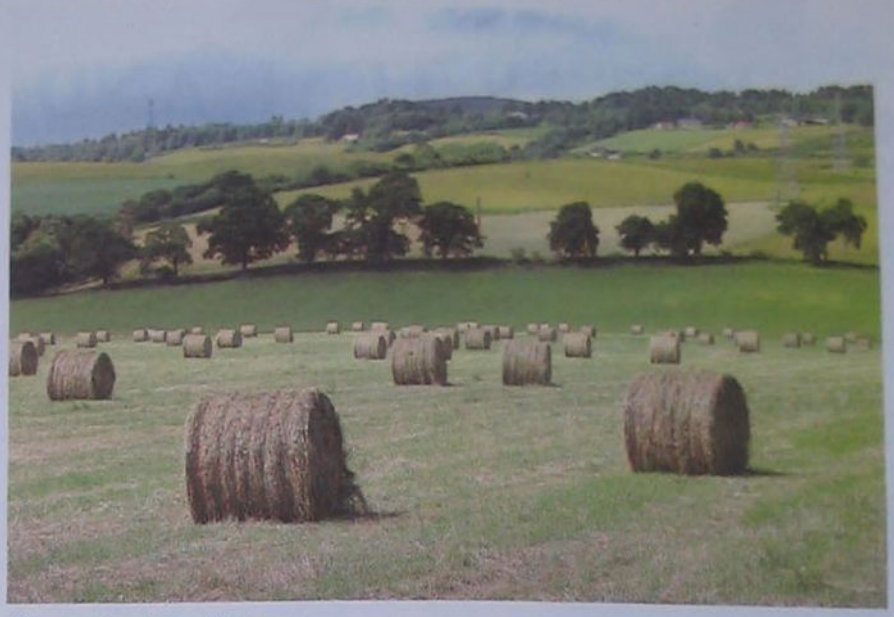
The next job is to bale the hay. The standard rectangular bale, designed for man-

Below: The sugar beet harvester first slices off the tops and throws them back on the field to be collected later for the cattle. The roots are then prised out and elevated into a tank or trailer. Most machines harvest two rows together.

ual handling, is popular with haymakers for its portability and the scope it allows for further drying. Drawn down the swathe, the baler picks up the hay and rams it into a chamber where it is automatically strapped with twine. The completed bale is then ejected on to the field, or into a bottomless sledge which accumulates eight bales before dropping them in a group for collection by a tractor equipped with a 'flat eight' fore-end-loader.

An alternative to this is the big baler, which simply rolls up the swathe into a big round bale, trusses it with twine and drops it. Designed from the start for mechanical handling, the bale is transported by impaling it on a tractor-mounted spike.

These baling systems are also used to collect straw in the harvest field, either for livestock bedding or, in the case of barley or oat straw, to add to the feed ration. Baled straw is, however, little use to the cereal grower with no livestock, and many farmers either plough it in or burn it. For this it helps if the straw is well scattered, and the combine may be fitted with a device to chop and distribute the waste straw instead of leaving it in a neat swathe for the baler.



Above: Swathes of hay are baled into huge rolls, transported on a tractor-mounted spike, stored and then fed to livestock throughout the winter.

Above: The key machine in silage-making is the forage harvester. It may be a big self-propelled contraption resembling a combine, or a modest implement drawn by a tractor. When making grass silage it is important that the moisture level is reduced, so the grass is cut and bruised using a mower-conditioner and then allowed to wilt in the swathe (foreground) before being picked up and chopped by the forage harvester. This wilting technique is used whenever the crop is too succulent for immediate storage, be it grass, lucerne, kale or even sugar beet tops.

Another way of laying in food for winter is to preserve the newly cut green forage in an airtight enclosure as silage. This technique requires more skill than haymaking but it is quicker, involves less work in the field, and is less dependent on good weather. It is practical with a much wider variety of crops, and the end result is similar in dietary value to fresh forage. The forage harvester gathers and chops the green crop, which is then emptied into a silo or, more commonly, a walled enclosure which is called a clamp. As the heap grows, it is compressed by driving a tractor over it, and finally covered with plastic sheeting held down with straw bales or old motor tyres.

Care must be taken that there are no leaks: if air is allowed to circulate, the silage will rot. Normally the crop is cut and allowed to wilt to reduce the moisture content before being harvested. Maize is normally dry enough to be put straight in the clamp, and it is often cut by the forage harvester itself, furnished for the occasion with an alarming display of toothed spikes which penetrate between the rows and sever the thick stems.

Root harvesting Whereas grain and forage crops are well suited to mechanical harvesting, roots are more awkward. The easiest to deal with are the types with a high water content used for stockfeed–certain varieties of turnip, swede and fodder beet–which can be levered out by inclined discs drawn along the rows. Since much of their great weight is water, however, transporting them off the field costs more than their worth, so many farmers feed them to their animals *in situ*.

In general the only roots worth the cost of transport are those with a high dry matter content, such as sugar beet and potatoes. Unfortunately they are the most difficult to harvest; they grow low down in the soil and their cash value makes careful handling imperative. Sugar beet can be lifted cleanly and efficiently by a specialised harvester. It is an expensive piece of equipment and only a big grower or contractor can justify the investment. It moves slowly down the rows, slicing off the tops of the plants; the roots are then prised out between inclined discs and elevated into a tank or trailer. Conical varieties are the easiest to extract, and light soil is preferred as it falls away from the root during the harvest. Potatoes are a greater problem, being unpredictable in location and almost indistinguishable from stones and clods. A digger-elevator excavates the potatoes and drops them to be sorted and collected by hired hands. More sophisticated machines can also sort and grade the crop, but in practice the odd stone still gets through, and many growers prefer to invest in a travelling shed occupied by a gang of sorters and packers; a mobile bastion of manual labour in an increasingly mechanised industry.

ALL-YEAR TEAL AND SUMMER GARGANEY

Teal and garganey are closely related species of small dabbling ducks, with two big differences: teal are at least 100 times as common as the rare garganey, and while teal are seen all year round in Britain and Ireland, garganey are summer visitors.

Above: Two teal ducklings taking the sun on a mossy resting place. The nest itself is a shallow cup, usually quite close to the water, in which the female lays between 8 and 11 eggs. She incubates them for about 22 days, and the young fledge in a further four weeks.

Left: The male garganey's white head stripe contrasts with its reddish-brown head, neck and chest. The underparts and sides are pale grey.

The teal and the garganey are the two smallest ducks regularly occurring in Britain. Both are dabbling ducks, obtaining their food from the surface of the water or by up-ending; the males are brightly plumaged, and the females a dull camouflaged brown. They are each about 38cm (15in) long and fly with very rapid wingbeats and considerable agility, jumping straight from the water when disturbed.

Green-striped teal The male teal has a distinctively marked chestnut head, with a bold green curving stripe on each side outlined in cream surrounding the eye. This stripe is outlined in cream, and runs from the eye to the nape. The back and flanks are a delicately patterned grey, divided by a broad white stripe following the line of the closed wing. The chest is spotted brown, and the belly white. The tail is black but the area just in front is creamy-buff. The bird has a black bill and grey legs. The female teal is brown all over, except for a pale eyestripe.

Mixed populations Some 5000–6000 pairs of teal breed in Britain and Ireland. They occur almost throughout these islands, but are more common in Scotland and northern England than elsewhere. They favour rushy or boggy areas of moorland with numerous small pools, such as occur widely in the upland areas, and they also breed beside lowland lakes, rivers and streams, provided there is plenty of thick vegetation in which to conceal their nests.

These native breeding teal are probably largely resident, only moving small distances in the course of a year. However, teal breeding elsewhere in Europe are highly migratory, and many tens of thousands come to Britain for the winter. Peak counts in Britain have reached as high as 100,000, though normal numbers are probably 75,000–80,000.

Wintering teal in Britain and Ireland favour shallow waters, both fresh and salt. Some of the largest concentrations occur on estuaries, for example the Mersey estuary in the north-west, the Essex marshes in the east, and in some of the south coast harbours. The Mersey estuary population is quite exceptional, and counts there have exceeded 30,000 birds.

Food requirements Teal feed mainly on small seeds and insects, and they obtain these by dabbling in fine mud and very shallow water, for example in estuaries and flooded fields. They walk or swim slowly forward, their bills submerged in the water and mud, filtering food items as they go.

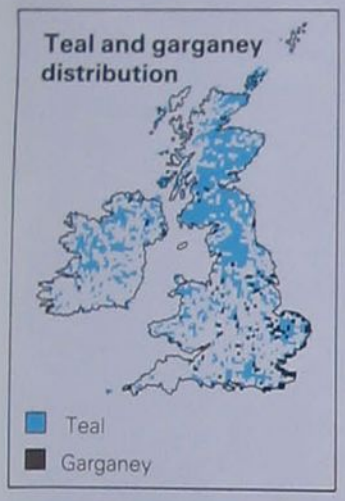
Hard weather movements Extensive catching and ringing of teal in different parts of Europe have revealed that the birds respond quite markedly to varying weather conditions. Spells of unusually cold weather cause the most marked teal movements, driving them away from their normal wintering range, often pushing them south and west to areas beyond the extent of the frost and snow.

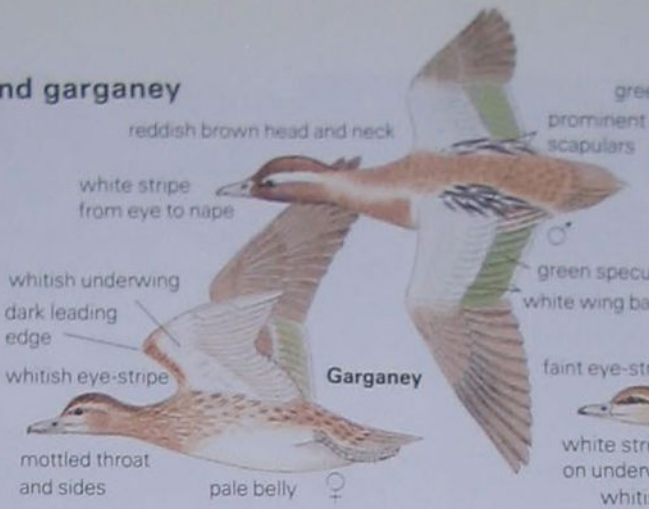
One example was the notorious hard winter of 1962–63, when the freezing weather lasted

Identification of teal and garganey

Teal (*Anas crecca*). Small dabbling duck. Resident, with large winter visiting population. 36cm (14in).

Garganey (*Anas querquedala*). Small dabbling duck. Summer visitor. Rare, with below 50 pairs. Virtually restricted to southern England. Length 38cm (15in).



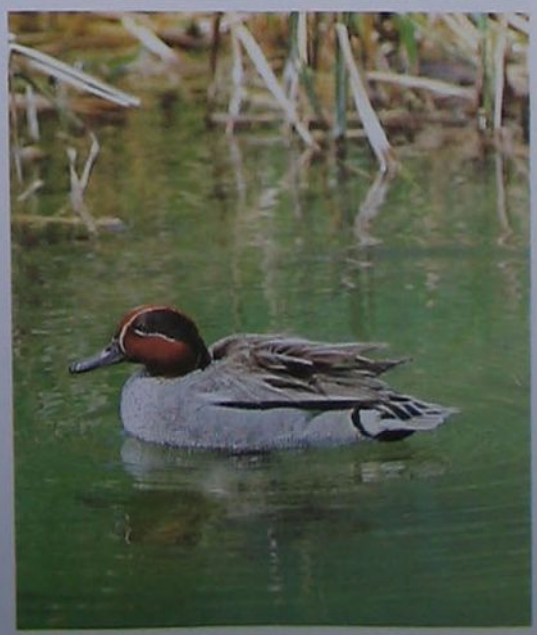


throughout January and February in Britain and Ireland. It is thought that the majority of teal wintering in Britain moved westwards into Ireland first, and then turned south for France. Even the west coast of France was not spared the grip of cold conditions, and so the teal had to move on even further, eventually reaching Spain and Portugal.

In all European countries there is an open season for shooting game birds and wildfowl –from around September to January or February. In several countries, including Britain, shooting is banned if there is a prolonged period of cold weather. This is done to reduce unnecessary mortality at a time when the birds may have become weak and confiding for lack of food.

However, the system has one major weakness: shooting may be stopped in the normal wintering range of the teal, for example in Britain and the Netherlands, but outside this area the need for the shooting ban is not appreciated. If the weather remains mild in France, shooting continues. Yet it is here that tens of thousands of teal are taking refuge –unfortunately, under exceptionally severe shooting pressure.

Above: Two garganey drakes. The garganey favours the same kinds of shallow floods and lakes as the teal, but is less often seen on the coast. It nests in thick vegetation quite close to water. Its food consists of a wide variety of seeds and aquatic insects.



Right: Teal frequent shallow freshwater lakes. They are also quick to visit areas flooded by heavy rain. When reservoirs are being filled for the first time, large flocks of teal often move in and feed in the gradually rising waters as these flush insects and seeds from the vegetation.

White-striped garganey The most obvious feature of the male garganey is the curved white stripe running from in front of and above the eye to the nape. It contrasts with the reddish-brown head, chest and neck, and pale grey sides and underparts. The female garganey is the usual camouflaged brown of most female ducks, but she has a noticeable whitish eye-stripe, a white spot at the base of the bill, and a white chin.

The garganey is the only species of duck that is a summer visitor to Britain, arriving in April and departing in September or October. It winters south of the Sahara, in West and East Africa. In Britain, the bird is more or less confined as a breeding species to the southern half of England, most pairs breeding in East Anglia and Kent. It is not common anywhere in the country, and has been declining in recent years. It was estimated that there were between 50 and 100 breeding pairs in the late 1960s, but since then the total has fallen below 50 pairs.

TREES: DESIGN FOR SUCCESS

A close look at the shapes of trees reveal some superb adaptations that allow them to become the largest organisms ever seen on this Earth.

From a very early age we are familiar with the fundamental design of a tree. Ask a young child to draw one and he or she will show a trunk and, somewhere above, branches and leaves. No other type of plant makes such an impact on us. Partly, this is due to the permanence of many specimens, but it is mainly their sheer size that impresses us.

Large size (usually at least 6m/20ft), along with a stout single stem at the base of the structure and leaf-bearing branches, are all features shared by almost every species of tree in the world. They must give trees important advantages over other plants, otherwise trees would never have survived and flourished in the wild. But what are these advantages, and why are trees designed the way they are?

Size and strategy A tree has a distinct advantage over smaller plants. It can overshadow them, filtering out the useful wavelengths in sunlight that all plants need for photosynthesis, so that very few other species can compete directly underneath. A corollary to this is that once trees become established in a favourable climate they are unlikely to be displaced by any other plants. It is not surprising, therefore, that most of Britain was covered by forest before man began clearing it–trees being the end product of natural plant succession.

The great height attained by some trees, however, presents considerable problems. Imagine what would happen if an herbaceous plant normally 30cm (1ft) high were the height of a tree–say, 30m (100ft)–yet were made of the same herbaceous materials. Because the height is increased by a factor of 100 the weight of this giant plant would be a million times greater than the normal herb. The materials which are quite strong enough to support a plant the size of a buttercup would be totally inadequate to support something the size of a tree. The sheer weight of the plant would cause it to collapse.

Trees partly overcome this problem by the

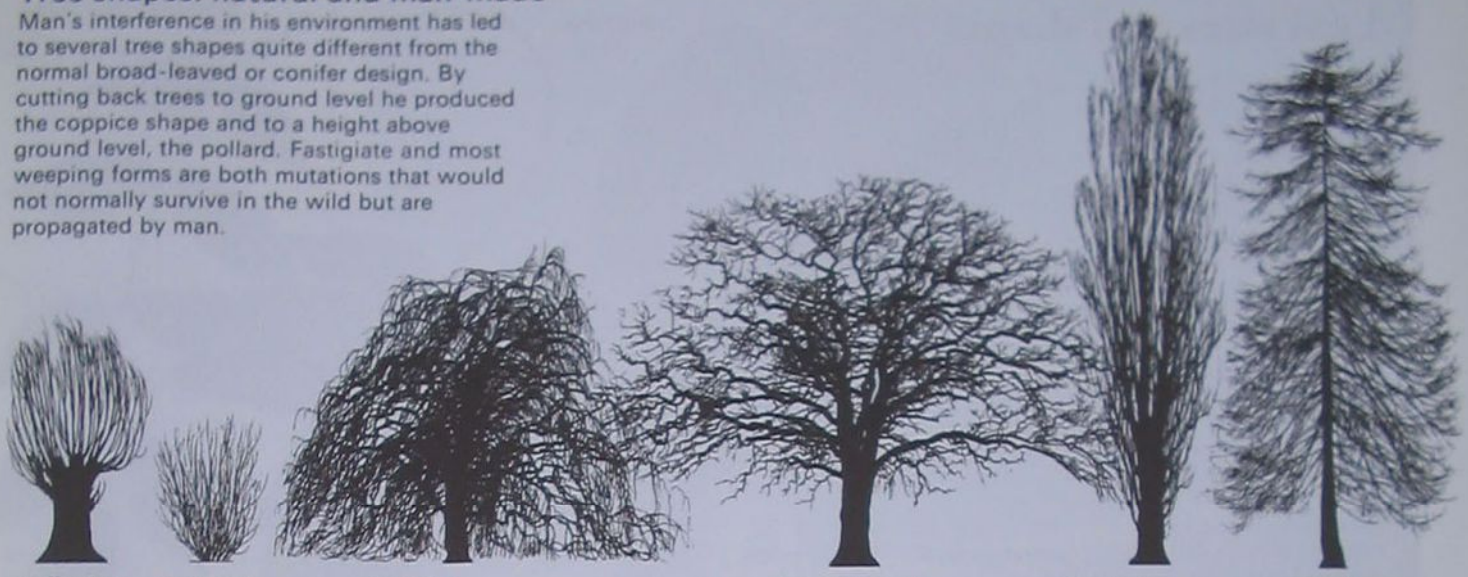
Above: Broad-leaved trees such as this sycamore have most of their leaves on the tips of their branches to catch as much sunlight as possible. For a tree to produce leaves inside its canopy tends to be a waste of valuable material because these leaves would receive much less sunlight and so produce less food.

Girth and age

The girth of a trunk gives a good indication of the age of a tree, though the results may be misleading for some quick-growing species or specimens that are very young, very old, diseased or overcrowded. Measure the girth (circumference) of the trunk at a height of 1.5m (5ft) above the ground. The answer will be 2.5cm (1in) for every year of the tree's age. Thus a tree with a girth of 2.5m (8ft) will be about 100 years old.

Tree shapes: natural and man-made

Man's interference in his environment has led to several tree shapes quite different from the normal broad-leaved or conifer design. By cutting back trees to ground level he produced the coppice shape and to a height above ground level, the pollard. Fastigiate and most weeping forms are both mutations that would not normally survive in the wild but are propagated by man.

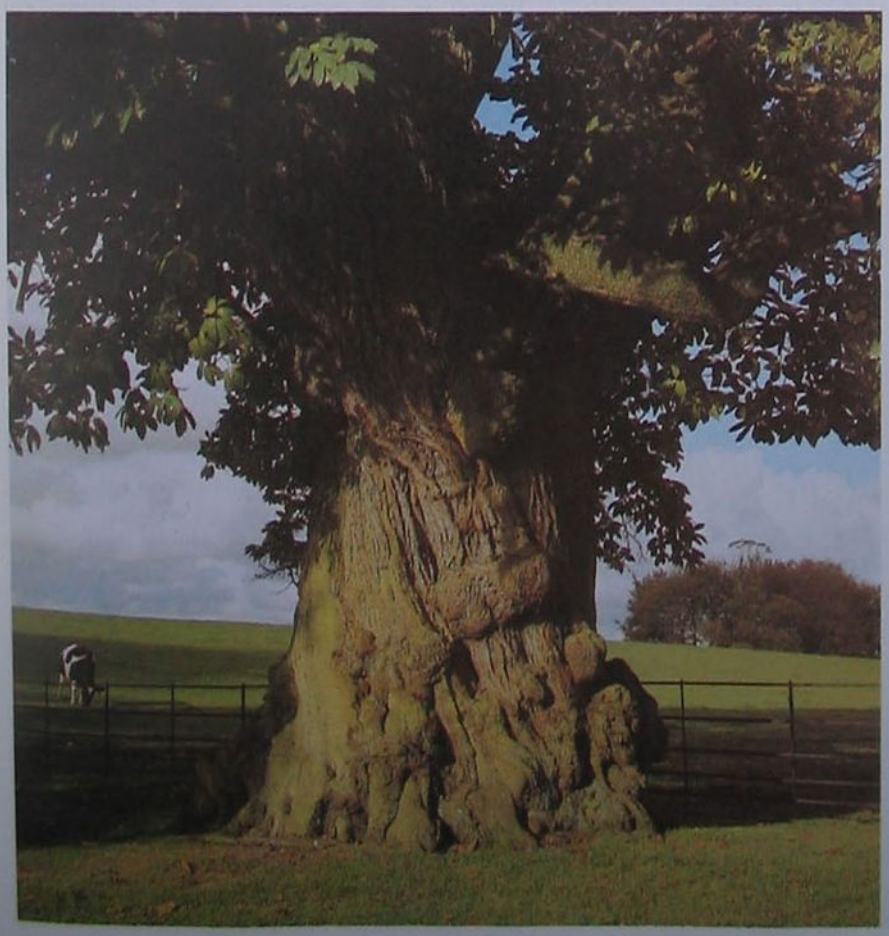


pollarded (beech) **coppiced** (hazel) **weeping** (weeping beech) **broad-leaved** (oak) **fastigiate** (Lombardy poplar) **coniferous** (larch)

Below: The tapering shape of a tree trunk (such as this trunk of an old sweet chestnut tree) so that it is widest at its base is the best shape for resisting the sometimes considerable forces exerted on a tree by the wind. This has been proved by wind tunnel tests and explains why tall chimneys are built to the same tapering shape.

way in which the cells in their trunk, branches and roots are constructed. As these cells die, various materials are laid down in them to strengthen the cell wall and so produce the material we call wood, a material that is not present in herbaceous plants.

Another way in which trees solve this problem is by having relatively thicker, straighter trunks than herbaceous plants–in exactly the same way as an elephant's legs are relatively much thicker and straighter than those of a mouse.



Importance of branches How does a tree manage to support enough leaves to manufacture the foods it needs yet, at the same time, keep the amount of materials needed for this to a minimum? The problem is solved by the tree's branching pattern.

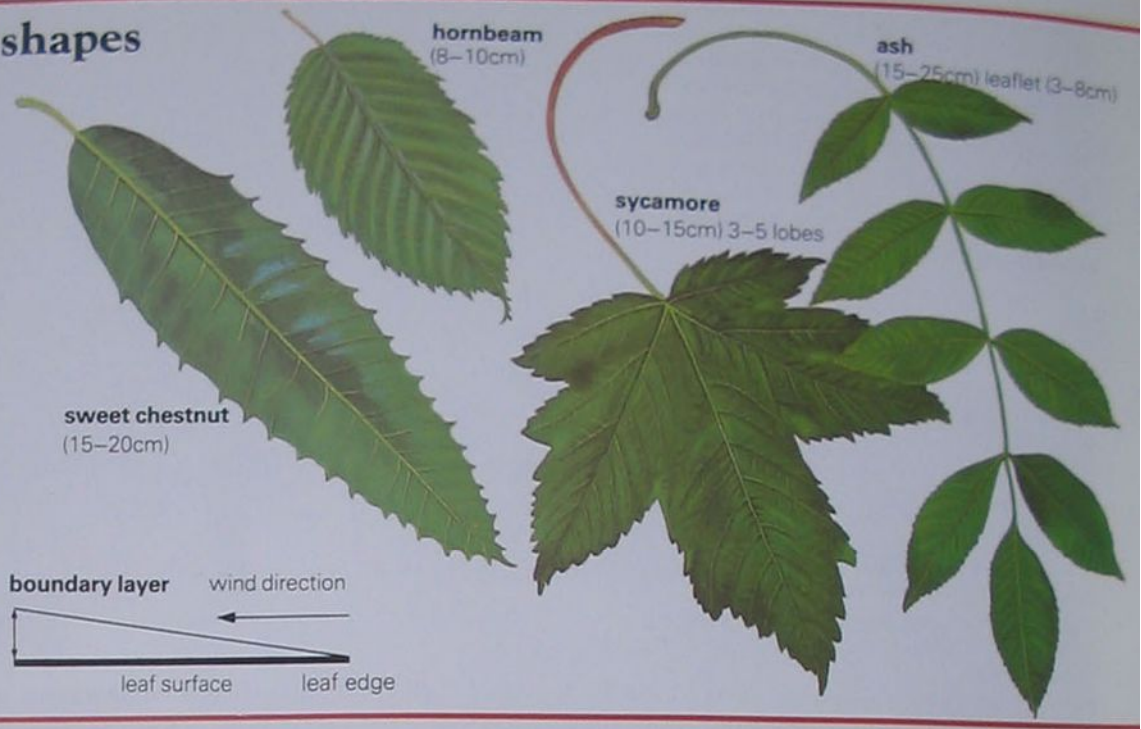
Imagine two extreme designs of tree. In one, all the leaves are connected to just one single stem that twists its way through every part of the leaf canopy. The advantage of this design is that it keeps to a minimum the total length of stem material needed. But the stem has to perform two functions: as well as supporting the leaves it has to transport fluids between them and the roots. And, as a plumbing system, this design of a tree is totally impracticable because, for a tree with, say, 100,000 leaves, the stem would have to be enormously long. (Incidentally, trees with unbranched stems do exist. They are palms, which overcome the disadvantages of this design by having few, very large, divided leaves.)

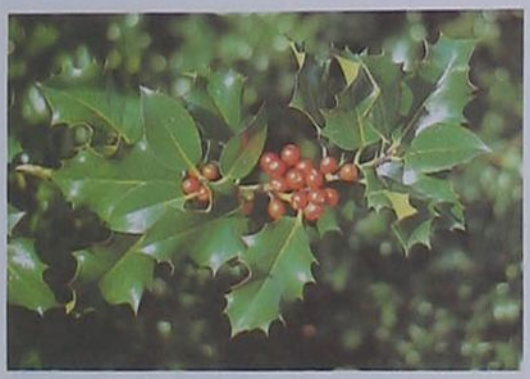
The other extreme design is where every leaf has its own stem arising directly from the ground. This would be a very efficient pluming system, because the average distance from a leaf to the ground is much less than in the first design, but it would be very wasteful of stem material. Such a design is, however, found among some small herbaceous plants and a few shrubs.

The actual design of a typical tree is a compromise between these two extremes, in which a single trunk from the base branches repeatedly until the ultimate twigs bear the leaves. This design is a remarkably good compromise between the two extreme examples given above because it makes the most of the advantages while minimising the disadvantages of each example. Branching makes the best use of stem materials and it also provides an efficient means of transporting fluids to and from the leaves.

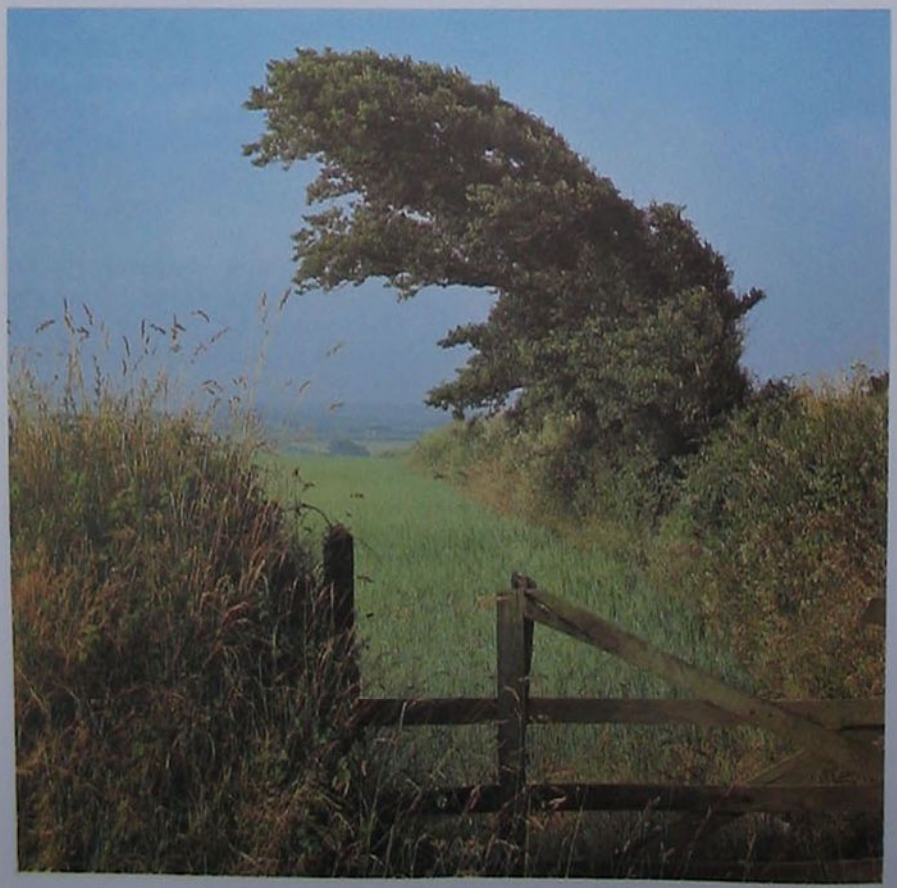
Leaf sizes and shapes

As air flows over the leaf surface it is slowed down and, just above the surface, forms a layer of still air–the boundary layer–which insulates the leaf and may overheat it. That is why large leaves like those of a sweet chestnut heat up more than small leaves such as a hornbeam's on a sunny day. Some trees evade this problem by adopting different leaf shapes such as lobing in the case of the sycamore or compound leaves like those of an ash. Both shapes reduce the build-up of the boundary layer over the leaf surface.





Left: Holly is one of the few European broad-leaved trees that are evergreen. To protect themselves from excess water loss during the winter, the leaves are covered with a thick waxy cuticle on the upper surface. The vast majority of broad-leaved trees, however, lose their leaves entirely to avoid the rigours of winter.



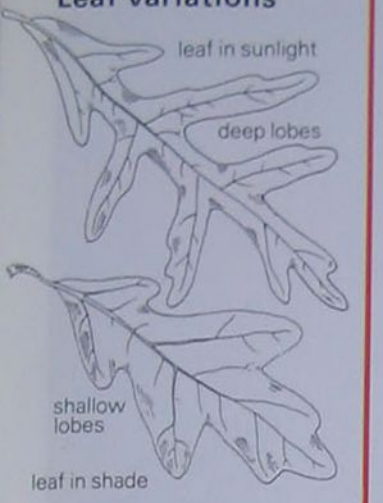
Branching angles Given that it is good design for a tree to have branches, does it make any difference at what angle these branches split away from each other? Without going into details here, it seems that it does. Engineers have researched the problem in connection with the amounts of materials needed for various construction designs, and they have discovered that a branching angle of 90° requires the least amount of materials (wood, in the case of a tree). Furthermore, scientists looking at blood vessels have discovered that the flow of blood is most efficient when smaller vessels branch off from main vessels at right-angles.

Yet, despite this, there exist trees with very narrow branching angles, resulting in a narrow columnar shape known as fastigiate. An example is the Lombardy poplar, a tree that probably arose as a spontaneous mutation of the ordinary black poplar. Without man's intervention such a freak would never have survived in the wild.

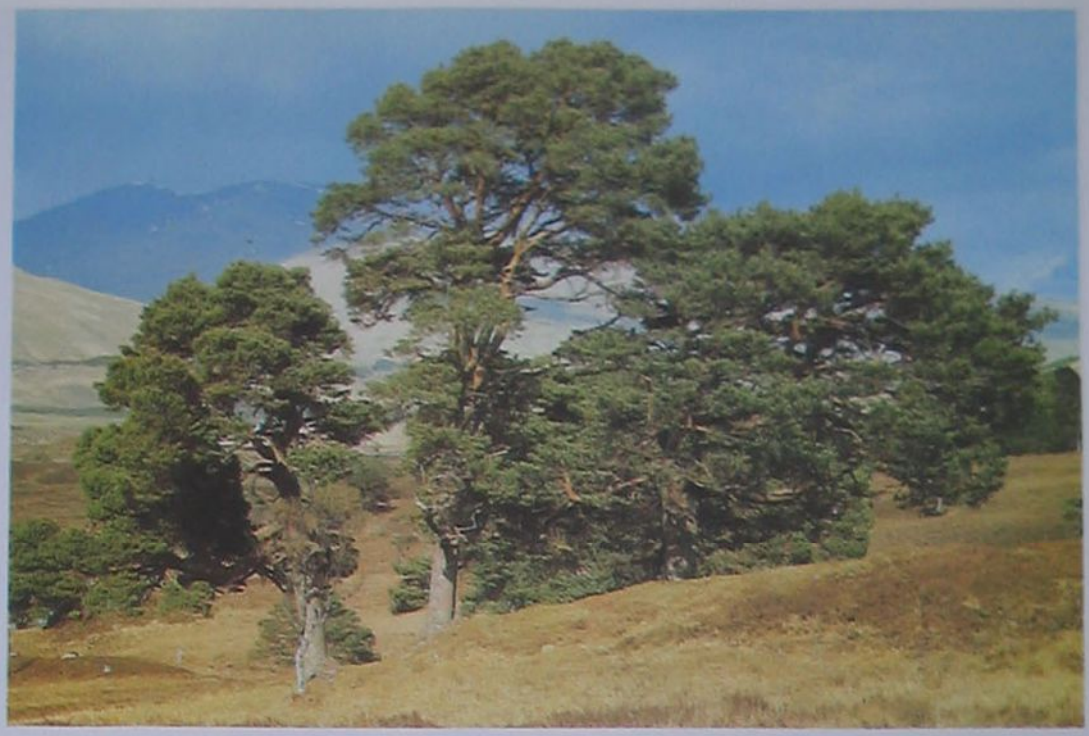
Weeping trees seem to be the opposite of fastigiate trees. Yet most have a normal branching angle. Their shape arises from the fact that the new wood grows too fast for the tree to be able to support its weight.

Small leaves The final major design criterion concerns the leaves. A large tree may have as many as a quarter of a million leaves, which are mostly orientated to catch as much light as possible. To this end they are arranged to form a mosaic with remarkably little overlapping between adjacent leaves. On most species the leaves are fairly small, usually less than 10cm (4in) across. Even those with larger leaves, such as the horse chestnut, tend to have the leaf lobed or divided into separate leaflets. The leaf is also thin, thus exposing the largest surface area for a minimum waste of leaf material. But the main design question is why

Leaf variations



The boundary layer effect is one reason why an oak leaf growing in the sun is more deeply lobed than one in shade.



Above right: The shape of a tree varies greatly with habitat. In an open habitat such as the Scottish Highlands, Scots pine matures to form its characteristic flat-topped crown. However, in the confined space of a plantation (see opposite right) a Scots pine takes on a very different shape: much more upright and narrow. Notice also that the plantation trees have lost the foliage on their lower branches.

Below right: The shapes of trees also vary greatly with age. The young Scots pine shown here has a quite different outline to either of the two mature specimens shown above. It has a much broader, conical shape than the plantation tree, and it lacks the flat-topped crown on the tree growing in an open habitat.

Opposite left: The weather can have a great effect on the shape of a tree. Branches can be broken by winds or lightning, and trees subjected to frequent gales can become stunted. Prevailing winds can also have their effect, causing the tree to develop on the leeward side only, so that it appears to lean with the wind–as shown by this elm growing near the north Cornwall coast.

have a large number of small leaves, rather than just one giant leaf?

Keeping cool The small size of leaves may, in part, be explained by the fact that on a sunny day a leaf absorbs much more heat than it can lose. On a hot day, even in this country, the temperature of a leaf can reach a lethal limit. The problem is made worse by the existence of a layer of still air–called the boundary layer–immediately above the leaf surface that insulates the leaf and prevents it from cooling. The larger the leaf the thicker this boundary layer becomes, so more numerous and smaller leaves, lobing and dividing into leaflets are all methods of keeping leaves cool.

There is another reason for having small leaves. In Britain, most of our broad-leaved trees are deciduous. Yet large leaves require disproportionately large veins, large leaf stalks, and a thick blade–all for exactly the same reason as a tree needs a thick trunk. To lose large leaves after just one season would mean a massive loss of hard-won material.

Small leaves with a lighter construction are far more efficient for deciduous trees. Really large tree leaves are restricted mostly to evergreen species of the humid tropics.

Design and evolution The gradual evolution of trees to their present design has, of course, been a process of natural selection. Natural selection has favoured particular designs over others, less suitable ones becoming rare or dying out altogether: those species best able to survive the rigours of their environment to produce offspring are more likely to be represented in later generations.

So today we see a very successful group of plants that have colonized a large part of the Earth's surface, and have produced the largest and also the longest-lived individuals in the world.

RED AND BLACK BEAUTY –THE CINNABAR MOTH

The adults and caterpillars of the cinnabar moth are a spectacular sight with their bright colour patterns, warning predators of the poison in their bodies. This poison is acquired by the caterpillars from their principal foodplant, ragwort–a plant always associated with the cinnabar moth.

The cinnabar moth belongs to the tiger moth family (Arctiidae) and, like most of its relatives, advertises its unpalatability through its striking and distinctive warning coloration. Its English name, dating from 1773, refers to the scarlet colour of its hindwings and forewing markings, while its scientific name, *Tyria jacobaeae*, indicates its chief larval foodplant, common ragwort (*Senecio jacobaea*).

The moth is quite unmistakable with its red and black markings, yet some people manage to confuse it with the burnet moths which have glossy blue-black forewings with crimson spots, and crimson hindwings.

Variations in the cinnabar moth's normal colour pattern are unusual, but sometimes individuals are found in which the red is pinkish rather than scarlet. Much more rarely the scarlet colour is replaced by bright yellow or even black, and occasionally the scarlet markings on the forewings become joined together. You may even see an all-red form.

The cinnabar moth and ragwort Cinnabar moths tend to occur in loose colonies, and are often abundant where the larval foodplants grow in profusion. Typically, therefore, they frequent well-drained pastures, heaths and sand dunes where the chief foodplant, common ragwort, is plentiful. This showy plant is

Above: A group of assorted cinnabar moths, showing the differences in colour form which can occur. Although most individuals are black and red, just occasionally you see variations such as the all-red forms. When disturbed during the day the cinnabar flaunts its warning colours, making little real attempt to escape. Birds and other potential predators soon discover their distastefulness which derives from a poison present in the moths' bodies and leave them well alone. This poison consists of high concentrations of histamine which are absorbed from the food plant during the larval stage. Consequently the caterpillars (right) are protected by the same poison as the adults. This they advertise with their distinctive yellow and black pattern, as they feed gregariously in full view of their predators.

especially characteristic of overgrazed pasture and is rarely found on wet ground; likewise, therefore, the cinnabar moth avoids poorly drained areas: its pupae die in particularly wet conditions, although they are extremely resistant to desiccation.

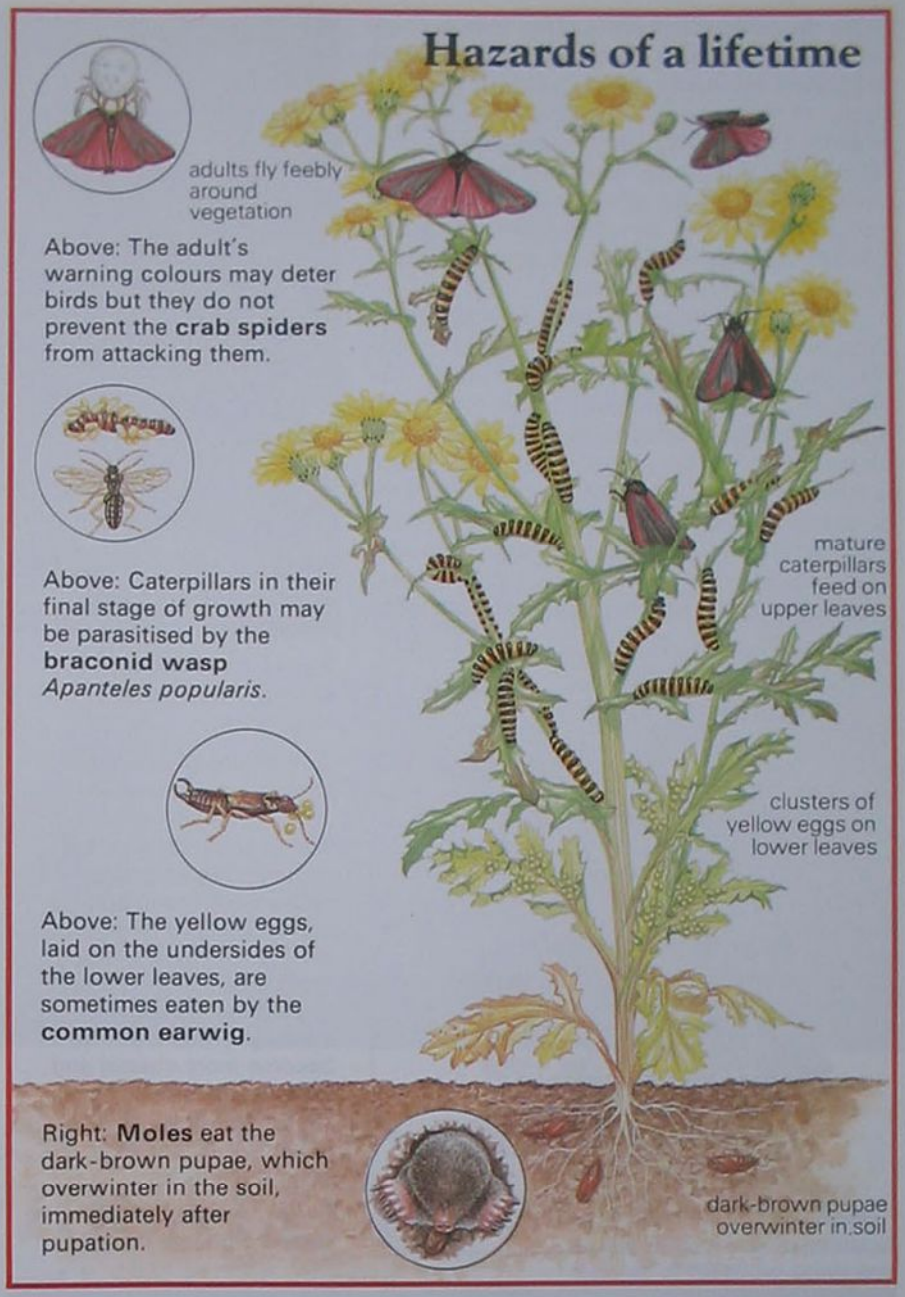
During this century cinnabar caterpillars have also been discovered feeding, to an increasing extent, on the alien Oxford ragwort, which is still spreading outwards from its strongholds in the southern half of England. This relatively new feeding habit has enabled the cinnabar to penetrate many urban areas, where it was hitherto unseen.

Cinnabar caterpillars also sometimes attack common groundsel and sticky groundsel –some were seen feeding on this species in Bristol– and they have occasionally been found on coltsfoot, a less closely related member of the daisy family.

Up-to-date research Our knowledge of the cinnabar moth has been greatly advanced by an exceptionally thorough study of cinnabar populations in Norfolk and Cambridgeshire made by Dr JP Dempster.

The female cinnabar lays her shiny, bright yellow eggs in clusters of 30 to 40 under the lower leaves of ragwort in May or June –sometimes as many as 150 are laid in a single batch. Dr Dempster calculated that few fail to hatch or are destroyed, the egg mortality rate ranging from 1.2% to 13.1%. The losses which do occur are a result of infertility, or because the leaves on which they are laid are eaten by rabbits or insect larvae, including cinnabar caterpillars which have already hatched. The eggs are also eaten by certain mites, ground beetles and common earwigs.

When the eggs are close to hatching in June or July, they become greyish and the tiny black heads of the caterpillars can be seen within. Newly hatched caterpillars are greyish-green, and they feed huddled together


Hazards of a lifetime
adults fly feebly around vegetation
Above: The adult's warning colours may deter birds but they do not prevent the **crab spiders** from attacking them.
Above: Caterpillars in their final stage of growth may be parasitised by the **braconid wasp** *Aparteles popularis*.
mature caterpillars feed on upper leaves
clusters of yellow eggs on lower leaves
Above: The yellow eggs, laid on the undersides of the lower leaves, are sometimes eaten by the **common earwig**.
Right: **Moles** eat the dark-brown pupae, which overwinter in the soil, immediately after pupation.
dark-brown pupae overwinter in soil

on the leaf where they were born, until the first skin moult. Unlike the caterpillars of many other moths, those of the cinnabar do not consume their egg shells.

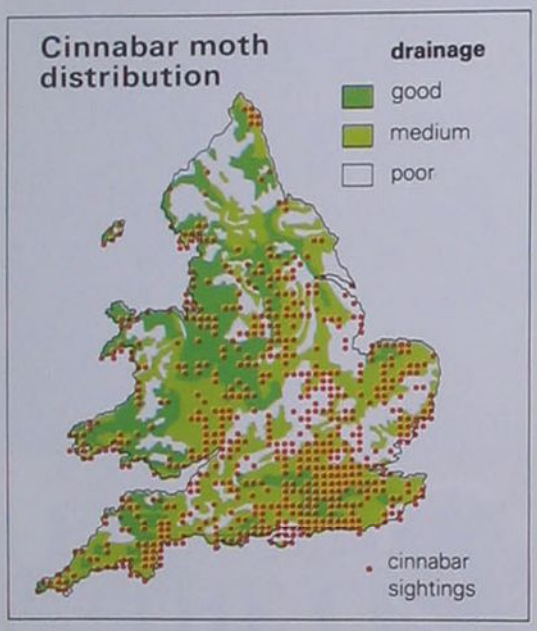
Predation pressures The caterpillars' warning colour patterns of black and yellow-orange bands are attained with their first skin change, when they also begin to move to the top of the plant. (If dislodged from their foodplant they drop on silken threads and climb back later.)

Caterpillar losses are much higher than those of the eggs, since although the warning coloration is very effective in deterring vertebrate predators (birds) it is ineffective against invertebrates such as spiders, harvestmen, mites and ground beetles. These take a heavy toll, particularly of the young caterpillars which are especially vulnerable, living as they do in tight clusters. There is some safety in numbers, however, as a higher proportion survive the attacks of a predator in a large cluster than in a small one.

As the caterpillars grow older they become less liable to attack from these invertebrate predators, but many die in their fifth and final stage of growth due to parasitism by the braconid wasp *Apanteles popularis*. The female of this wasp lays her eggs in the caterpillar's first or second stages of growth and several larvae develop within its body, finally breaking out of the dying caterpillar when it is near to pupation,

Starving themselves to death In some years cinnabar colonies become so populous that the caterpillars completely defoliate the ragwort plants, leaving only leafless stems. In one such population studied by Dr Dempster, about 20% of the caterpillars died from starvation. The following year the ragwort plants were stunted due to the ravages of the cinnabar caterpillars the previous summer. The caterpillars, however, were again numerous; this time the ragwort was even less able to support them and, early in the season, almost 50% of them died from starvation.

Above: The magnificent adult cinnabar moth (*Tyria jacobaeae*).



Left: A distribution map showing the cinnabar moth's preference for well-drained soils where common ragwort, the caterpillars' foodplant, grows. Despite these constraints the cinnabar moth is common in most of England and Wales, although it thins out to become more coastal and local as one travels north, so that in Scotland (and Ireland) it occurs only around the coast.

Below: An extremely rare yellow cinnabar moth.

The destruction of the available foodplants in this way leads to a crash in the cinnabar's population, thus enabling the ragwort to recover reasonably quickly, often by regenerating from the root buds. This in turn, allows the cinnabar population to recover well. Extinction of the moth is avoided on such occasions because the earliest caterpillars to hatch manage to complete their development while there is still some ragwort left.

Biological control Common ragwort, regarded as a pest of pasture since it is mildly poisonous to some livestock, has become a serious problem in many parts of the world where it has been artificially introduced. As the cinnabar caterpillars can completely defoliate ragwort, they have been introduced into some of the worst-affected areas (Australia and North America) in an attempt at biological control.

The results, however, have been rather disappointing because of the plant's rapid powers of recovery, by regenerating from the roots when its seed production is curtailed.

Threatened by moles In July or August when the one month old caterpillars (now 2.5cm/1in long) are ready to pupate they leave the foodplant and spin flimsy, silken cocoons just below the surface of the soil–often under small stones or among grass roots. Within the cocoons they change to dark-brown pupae with reddish rings and overwinter–but not without danger to their lives, for many are eaten by moles.

The adult moths, whose wingspans vary from 3.2cm (1¼in) to 4.5cm (1¾in), emerge between May and mid-July, and may be encountered flying by day or night. During the daytime they are easily disturbed from the vegetation, but fly weakly and soon settle down. After dark they seem to fly more actively and are often attracted to artificial light, especially late at night.

ISLANDS: ISOLATION AND INDIVIDUALITY

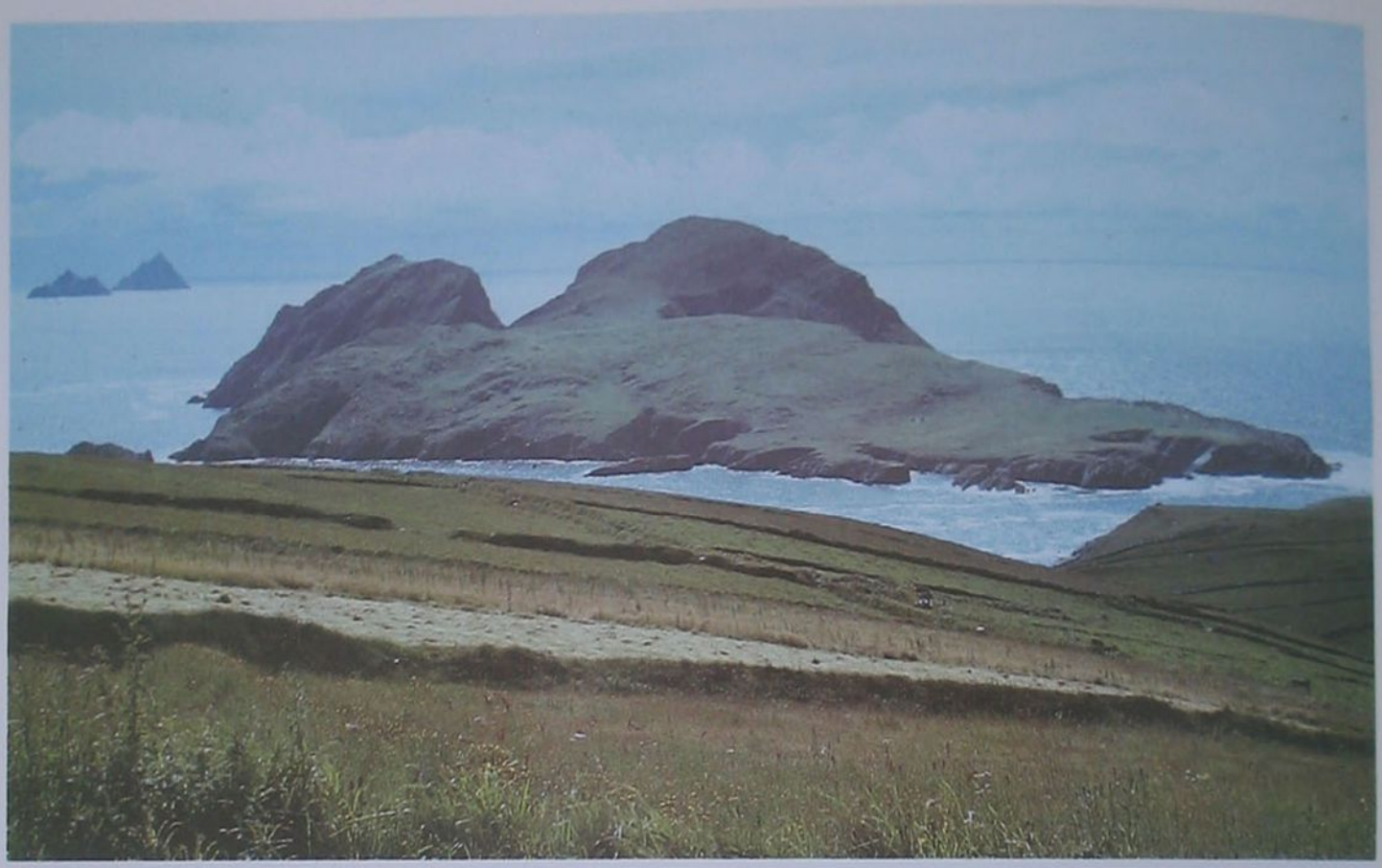
The offshore islands of Britain and Ireland and, indeed, these two islands themselves, were separated from the Continent by rising sea levels after the last Ice Age. Among the effects of this isolation on our flora and fauna are the development of distinct island races and the survival of 'relict' species.

Above: View of one of the Scilly Isles at low tide. The Scillies and the Channel Islands have a number of species of flora and fauna that do not occur anywhere else in Britain–for example, a species of meadow grass and a species of bird's-foot trefoil.

Below: Manx Loughtan sheep–one of several surviving hardy breeds of island sheep in Britain.

We live on an island, a Continental one which has not long–in geological terms–been separated from the rest of Western Europe. For the last two and a half million years changes in climate and sea level have occurred together as the ice sheets advanced and retreated over the north European landmass. During the many (probably 20 in all) interglacial periods the climate and sea level were much as they are now, and ten thousand years ago, as the ice sheets from the last glaciation retreated northwards, Britain became separated from the rest of Europe.

As the climate improved, birch and pine, then hazel, oak and alder all spread northwards and with them a whole assemblage of

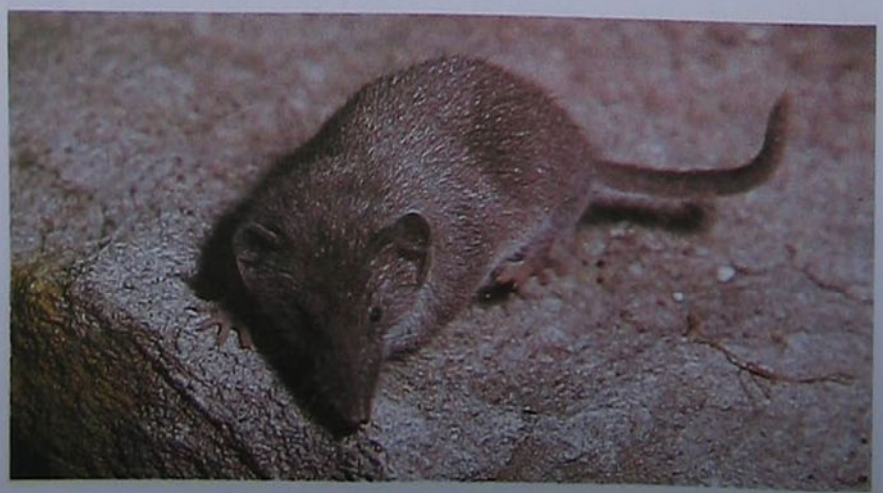


other plants and animals. During the glaciations much of northern Britain was under a thick blanket of ice, which swept over western and northern Scandinavia. Consequently it is unlikely that many organisms survived in these regions and the great bulk of Britain's present flora and fauna is derived from further south.

The most notable feature of an island is its isolation. As soon as Britain separated from Continental Europe a barrier to further movement by animals and plants arose. Some species, such as strong-flying birds and some wind-dispersed plants, would not have been deterred by this barrier, but those with low powers of dispersal were likely to remain on the Continent of Europe. Furthermore, the more distant a region is from the climatically favourable lands of southern and eastern Europe, the fewer the species which will colonize it. It is partly for this reason that of the 260 flowering plants of Continental affinity that entered Britain, less than half continued on to Ireland. Many of the Irish species we see today entered via the land bridge that connected Ulster with Galloway, although the country was not very hospitable for wildlife following the glaciations.

Above: Puffin Island, off the coast of County Kerry in Ireland. By no means all the plant and animal species colonizing Britain after the Ice Ages managed to reach Ireland. Species absent from Ireland include woodpeckers and such warblers as the reed warbler and nightingale (probably because of the earlier lack of suitable woodlands), the common shrew, weasel, slow-worm, adder and palmate newt.

Below: A white-toothed shrew—two species of these shrews are found on the Scillies and Channel Islands but occur nowhere else in Britain.



Ten thousand years ago a stretch of land existed linking the promontories of south-west Ireland, south-west Wales, Cornwall and Brittany. This, called Armorica, forms an important link between the flora and fauna of these regions. As the sea levels rose, much of this land was drowned to form the waters of the Celtic Sea, and the land bridge from the Mediterranean up the west coast of Europe was broken. Some species, for example the strawberry tree and a shore-living bug *Aepophilus binnairei*, managed to travel the full length of the route to the islands of Lough Gill in Sligo, but many clearly did not make it. Less than half of the 105 flowering plants of Mediterranean/Atlantic affinity that reached Britain succeeded in reaching Ireland.

Isolation and relict species Although much of Britain was glaciated during the Pleistocene era, we should not imagine a continuous sheet of ice without any form of life. During much of this period there was probably a tundra landscape, with birch and willow scrub spreading during the interglacials. This has resulted in what are termed relict distributions for a number of species. An example is mountain avens which at present is confined in Britain to certain mountain tops—on Ben Bulben (western Ireland), in Snowdonia, the

Lake District, the Grampians and the Scottish Highlands. Elsewhere it occurs in Scandinavia and the alpine areas of Europe.

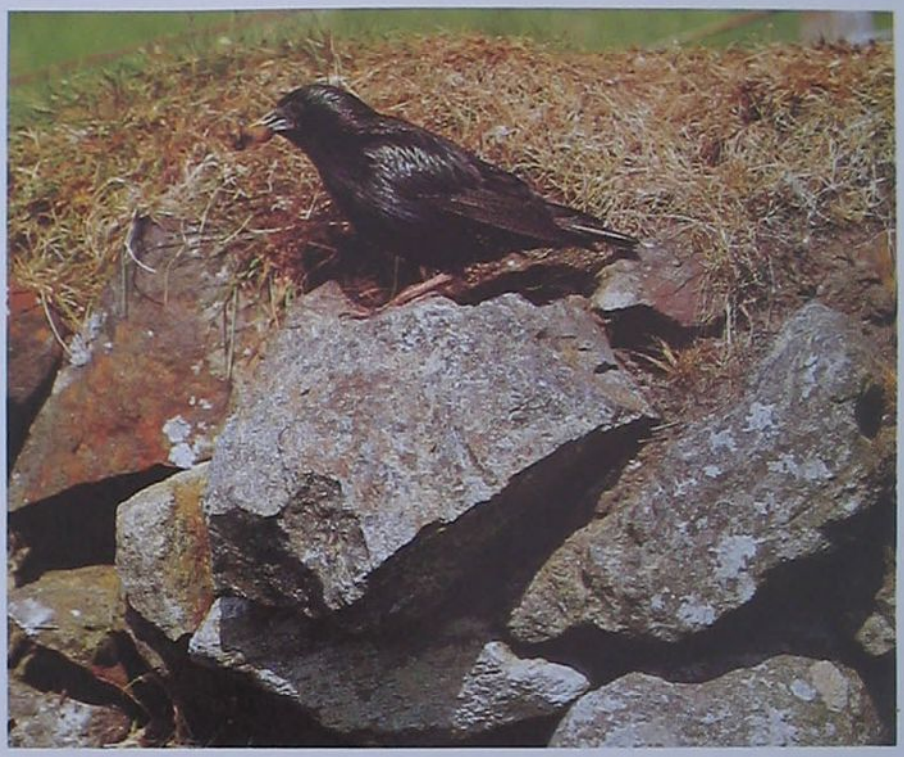
Mountainous areas such as those mentioned above may be regarded as 'ecological' islands. Although not isolated by water, they are separated by areas of apparently unsuitable habitat. Other species with relict distributions are dwarf birch and least willow.

Of the species or races on 'geographical' islands (that is, sea-girt areas of land) around Britain, virtually none can be considered as Pleistocene relicts. For instance, *Koenigia islandica*, a member of the dock family, occurs in Britain only on the Isles of Skye and Mull off western Scotland, where it was discovered only 30 years ago. Elsewhere it is found in the Arctic as far north as 80°N in Spitsbergen. South of the main ice sheets, the rise in water levels created the Isles of Scilly and the Channel Islands. The fauna and flora of these include a number of species which do not occur elsewhere in Britain though they are not uncommon on the Continent. For example, two species of white-toothed shrew in Britain are confined to these two groups of islands, while a species of bird's-foot trefoil, *Ornithopus pinnatus*, and of meadow grass, *Poa infirma*, are also all but restricted to them. The island of Jersey has a number of named plant species, for example Jersey forget-me-not (*Myosotis sicula*), Jersey buttercup (*Ranunculus paludosus*), Jersey toadflax (*Linaria palisseriana*), Jersey cudweed (*Gnaphalium luteoalbum*), and Jersey club-rush (*Scirpus americanus*).

Size and climate Isolation is but one characteristic of islands. The size of an island determines to a large extent the variety of habitats it possesses. The small island of Bardsey off the Lleyn Peninsula of North Wales, for instance, primarily consists of heathland and rough pasture, whereas the nearby but larger island of Anglesey has a much wider range of habitats, including moorland and woodland, freshwater marshes, lakes, dune slacks, pasture and cereal crops. Where there is a greater variety of habitats, there are also more species of animals, since each has its own particular ecological requirements. Thus Bardsey Island has 45 species of land birds breeding on it, while Anglesey has more than double this number with 98 species. Although land area and number of habitats are correlated, recent studies suggest that it is the latter which is most important in determining the number of animal species on an island.

Right: The Glanville fritillary butterfly is a species which occurs on one of our islands–the Isle of Wight–but not elsewhere in Britain.

Below: A Shetland starling. One interesting feature of island populations is a reduction in the clutch size of birds. The race of starling on Fair Isle, for example, lays on average one egg less than its mainland Scottish counterpart.

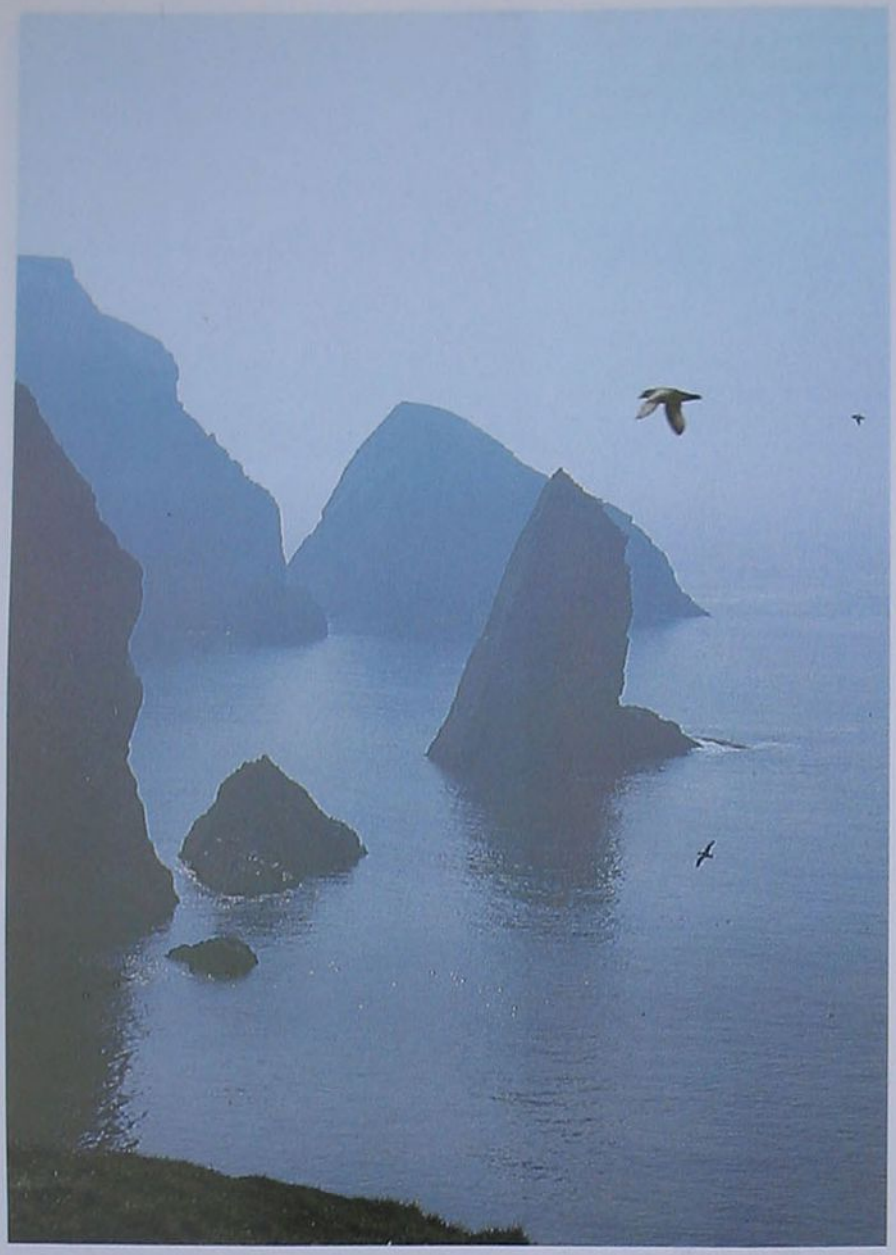


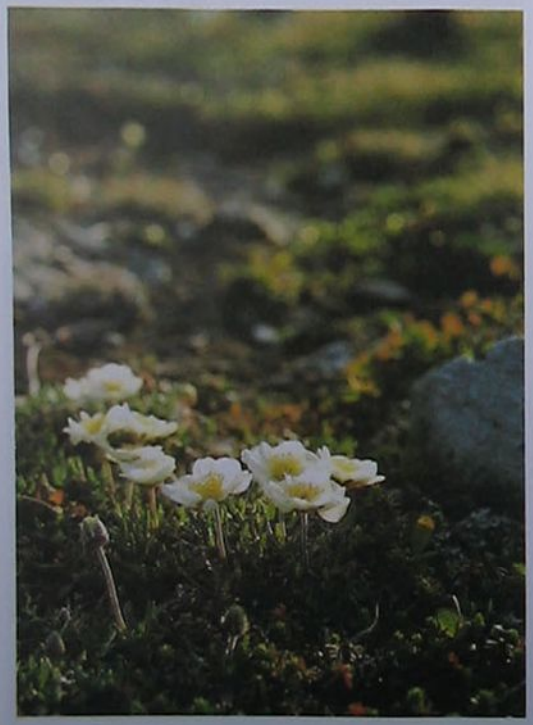
Below: The grass snake is yet another of the species found over most of England, Scotland and Wales–but is absent from Ireland. To balance this lack, Ireland has some species–the strawberry tree for instance–not surviving anywhere else.

Britain, Ireland and their offshore islands have an oceanic climate, lying as they do on the edge of the North Atlantic. This results in equable temperatures with warm summers and mild winters (with little or even no frost). Animals that are sensitive to harsh winters (such as wrens) may therefore often be found on islands where otherwise they might succumb.

Independent evolution As soon as an island is formed and routes of entry for migrating animals and plants are cut off, populations and communities of organisms start to evolve independently of their neighbouring relatives.

Some species will become extinct–the more so if the island is small and able to support only a small population, or isolated so that it





Above: A view of Fair Isle (sited between the Orkneys and Shetlands). Mammals have poor powers of dispersal and it is probable that most island populations derive from accidental introductions by man. For instance, the Scottish island races of field mouse on Fair Isle, Foula and St Kilda show some resemblance to Norwegian mice, from which they may have come in the 8th and 9th centuries during the Viking raids and subsequent colonizations.

Left: Mountain avens is one of a number of 'relict' species found in Britain. Such species, widespread in the lowlands of Britain during the late glacial period, are now found only on certain mountain tops.

receives few colonists, or if climatic conditions are variable so that when they become unfavourable the species cannot seek refuge elsewhere. Other species, however, will arrive –depending on a combination of chance, their powers of dispersal and a neighbouring source population (or assistance by man). However, even if a species finds its way to an island, its chances of colonizing that island are by no means assured. If a species with similar ecological requirements already exists on the island, the immigrant may not be able to compete with it. Likewise, if the ecological requirements of the immigrant species do not suit the habitat(s) in which it finds itself, extinction may follow.

Population size and genetic drift Small population size is often a feature of island species. This has two important consequences. First, it leaves the species vulnerable to extinction. The song thrush, for example, occurs all over the British Isles including Orkney, except in Shetland. It established itself on these latter islands around 1906 and by the 1940s there were about 24 breeding pairs. However, after the severe winter of 1946-7, the population declined and then became extinct.

The second consequence is a genetic one. When there is only a small founding population, the members are more likely to have a non-typical set of genes, different from those of the source population–and so appear different in size, colouring etc. This is known as the Founder Effect, a form of random genetic drift. There is still much argument as to the relative importance of this against local adaptation from selection pressures in the absence of movement elsewhere. At present there is no good evidence to support one argument rather than another for a particular island population.

Differences in island races Many island races or species of birds and small mammals are larger than those on the adjoining mainland. Examples are the Orkney and Skomer voles, the field mice of Great Blasket, Fair Isle, St Kilda and Foula, the house mice of Skokholm, the Shetland starling (on Fair Isle, Shetland and the Outer Hebrides), and the wrens of Fair Isle, Shetland, St Kilda and the Outer Hebrides.

A number of theories have been advanced to account for this general increase in size. It may be that the founding populations were of larger size, although for the birds at least this seems rather unlikely. It may be that the lack of ground predators–a feature of all these islands–has lowered the predation rate and hence reduced selection favouring small size, but again this seems unlikely to apply to the large races of birds. However, perhaps the most likely explanation is that the local climate plays an important role, with large size favouring the ability to retain heat and to store food as fat to withstand unfavourable conditions from which there is no escape.

Above: A female marsh fritillary on one of the spotted orchids. This species lays her eggs (below) in batches on the undersides of devil's-bit scabious leaves, where they take three to five weeks to hatch.

THREATENED FRITILLARIES

The marsh fritillary, heath fritillary and Duke of Burgundy are three brightly coloured butterflies whose existence is threatened by changes in land use.

Britain is fortunate in having eight resident species of fritillary butterfly. In addition to the true fritillaries (family Nymphalidae) our fauna also includes the so-called Duke of Burgundy fritillary–a small black and orange chequered butterfly belonging to the family Nemeobiidae. Because of its similar appearance the Duke of Burgundy is often grouped with two other small fritillaries–the marsh fritillary and the heath fritillary. All three species are found in small colonies.

Marsh fritillary As its name implies, the marsh fritillary is found in discrete colonies in wet fields and on the moors of western Britain; it also occurs on the dry chalk grasslands of southern England, where there is an abundance of the larval foodplant, devil's-bit scabious.

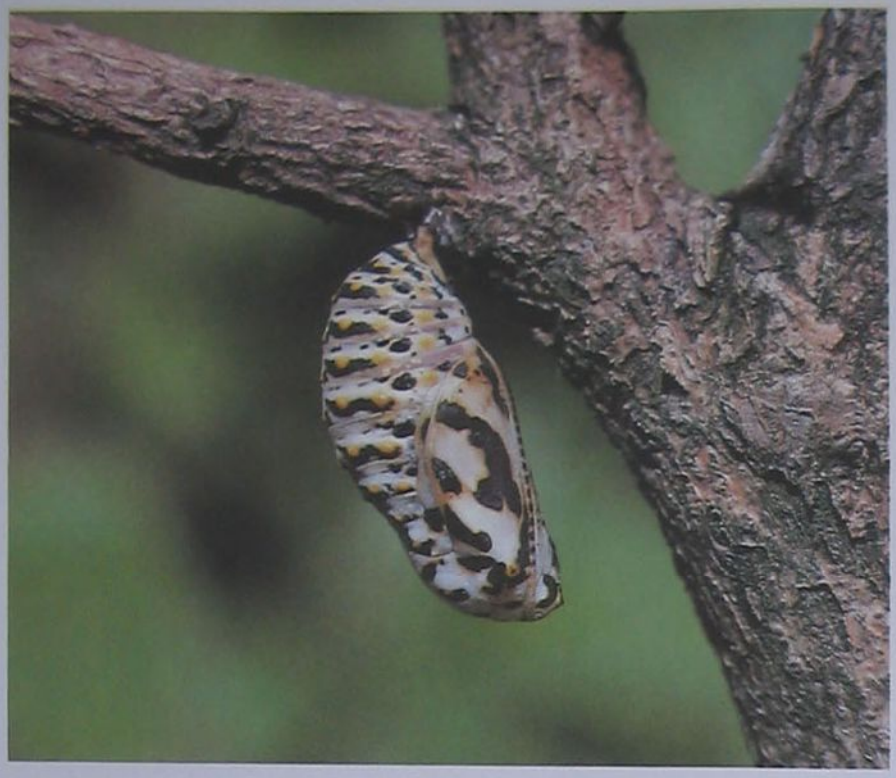
The female marsh fritillary is unusual in that she only mates once, the successful male secreting a substance which seals off her genital opening after mating is complete. The female lays her eggs in batches of around 350, each individual laying one large batch as a rule, although if the weather is favourable the females feed on such flowers as betony and tormentil and lay a few more smaller batches comprising about 100 eggs.

Caterpillar sandwich The egg batches are laid on the undersides of devil's-bit scabious leaves and take three to five weeks to hatch. The newly hatched caterpillars then spin silken strands which attach their leaf to the one beneath, forming a sandwich of leaves and caterpillars. Inside this silken sandwich the caterpillars feed gregariously on the leaf epidermis, leaving a distinctive brown patch on the upper surface of the leaf. After this secretive feeding phase the caterpillars spin a white silken web over part of the foodplant.

Caterpillars which emerge from the eggs laid in June should have reached their fourth stage by late August, when they go into hibernation. Once ready to hibernate the communally feeding caterpillars spin a tough ball of silk, inside which they pass the winter.

The following spring the caterpillars are awakened by the first warming rays of the sun and recommence feeding. As they develop through a further two stages the previously tight aggregations of caterpillars begin to disperse and feed individually. By May they are fully grown, black and spiny, and can be found spinning small silken pads on the undersides of leaves from which they suspend their chrysalids.

The adults emerge after two to three weeks as chrysalids, usually in the first few days of



Above: You are most likely to come across the marsh fritillary's chrysalis–greyish in colour with black and orange streaks and blobs–in May. The adult butterflies emerge at the beginning of June.

June in southern Britain. Males survive four to five days on average, but females live only three to four days in normal years.

Parasitic threat Colonies of marsh fritillaries can fluctuate in size from a few hundred butterflies one year, to none a year or two later. These fluctuations are thought to be due to a tiny parasitic wasp, *Apanteles bignelli*, which lays its eggs in marsh fritillary caterpillars. In some years over 70% of all caterpillars are attacked by this wasp and eventually die as the parasitic larvae develop inside their bodies.

Other reasons for these fluctuations in colony size are that weather conditions may influence the number of eggs laid by the females, thus controlling the butterfly population the following season. In years of exceptional abundance the caterpillars may eat all the devil's-bit scabious plants in their area; they then resort to feeding on other plants, such as honeysuckle, in nearby copses and hedges.

Heath fritillary An elusive butterfly, the heath fritillary is found only in open, sunny situations in young plantations and woodland clearings in the south-west and south-east of England. In these two regions the heath fritillary appears to have two different food-plants; ribwort plantain in the south-west, and common cow-wheat in the south-east. Both these plants flourish in early successional woodland in sunny areas. Colonies of the heath fritillary never occupy the same site for more than a few years, moving on to new clearings as the old sites become overgrown.

The life history of the heath fritillary is similar to that of the marsh fritillary. Eggs are laid in batches of up to 120 and the caterpillars feed communally for a while. They hibernate in small groups in late August and feed individually after awakening in spring. The adults appear earlier in the south-west of England, usually around mid-June, but in the south-east they are not seen until late June or July.

Territorial male In contrast to the previous two species, the Duke of Burgundy is not a truly colonial species. The natural habitat of this butterfly is woodland clearings, but many of the southern English localities for the Duke of Burgundy are on scrubby chalk hillsides.

The Duke of Burgundy is associated with perky territorial males. Each male adopts a favourite perch, usually a grass-head or prominent shrub, from which he scans his domain. Any butterfly, or even bumble bee, coming within a metre or so of his perch is intercepted or chased off, but if the intruder is another male Duke of Burgundy they embark on a spiral flight high above the ground. Eventually the defending male returns to his territory, often the same grass-head, and continues to protect his patch. Males may remain on the same territory for most of their short lives, only leaving it temporarily to feed on nectar from tormentil or wood spurge.

The females are not often seen since they avoid the males once they have mated, and concentrate on the important task of egg-laying. For this they choose large, well-exposed cowslips or primroses, laying batches of one to eight eggs carefully under the leaves.

The small caterpillars hatch from their

Putting all the eggs in one basket

Marsh fritillaries (and heath fritillaries) lay their eggs in large batches, producing groups of caterpillars which spin webs and feed together (above). Since the caterpillars' black or dark brown colour causes them to be particularly conspicuous to predators, why do they remain in these large aggregations?

Although an obvious target for hungry birds, they are collectively protected by the sharp spines and by the poisonous chemicals in their bodies. They also gain some advantage by basking in large groups. Small temperature probes placed among clusters of basking caterpillars show that in spring, when air temperatures are only just above freezing, these caterpillars can attain a body temperature of 34-37°C (93-98°F)–the aggregated caterpillars help each other to warm up by absorbing the sun's rays. This warming up enables the caterpillars to digest food quickly and grow rapidly in time to produce adult butterflies in June, which can then mate and reproduce.

Marsh fritillary

Right: The marsh fritillary (*Euphydryas aurinia*) is a small butterfly with a wingspan of only 3.4-4.2cm (1¼-1¾in), the females being slightly larger than the males. Otherwise both sexes are similar. The upperparts of their wings are bright orange in colour with black, cream and orange-red chequered markings, although the pattern can vary noticeably from region to region. In western Scotland and Ireland, for instance, there is a greater contrast between colours, with the creams being paler and the reds deeper, than on the individuals in England and Wales. The underwings of marsh fritillaries, seen clearly in the mating pair (far right) are much paler than the upperparts, although the pattern is similar, but without any black markings. The adults are usually seen on the wing in June.

pearl-like eggs and nibble small 'windows' out of the leaves. When older they resemble pale brown, hairy woodlice and hide in leaf litter away from the plant during the daytime, but as night falls they shuffle out to feed on cowslips or primroses, eventually reducing entire plants to skeletons of tough leaf veins. The chrysalids are formed on the ground and remain dormant until the following May when the adults emerge.

Fritillary distribution The distribution in Britain of all three species is restricted, and only the marsh fritillary can be found outside England. Even this is declining in England and Wales due to loss of habitat caused by drainage and changes in the land use. Indeed this species is now naturally absent east of a line drawn from Portsmouth to Leicester.

The heath fritillary was well on the way to being our third species to become extinct this decade, recent actions having just saved it from the brink of disaster. It is now a species protected by law, and anyone catching a specimen may be fined up to £2000.

The Duke of Burgundy is fairly well spread over England, but absent from other parts of the British Isles. However chalk grassland sites are no longer being grazed intensively and are reverting to scrub. This prevents the cowslips from growing, thereby destroying the Duke of Burgundy's chief foodplant, so leaving nothing for the caterpillars to eat.

Heath fritillary

Right: The heath fritillary (*Mellicta athalia*) has rich orange-brown upperwing surfaces with black chequered markings; its underwings (far right) are noticeably paler with yellowish markings (lunules) bordered with black. Both sexes look extremely similar, differing only in size, the females being larger than the males. They have a wingspan of 3.6-4cm (1½in).

Duke of Burgundy

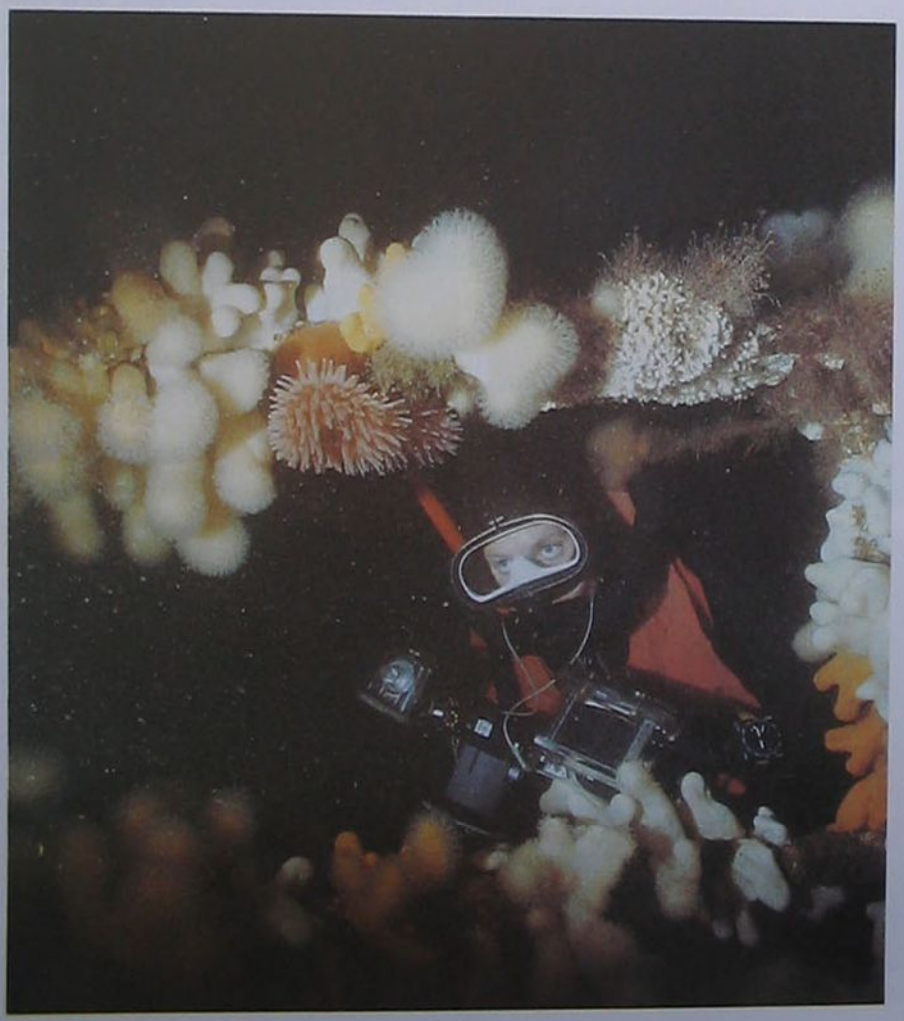
Right: The Duke of Burgundy fritillary (*Hamearis lucina*) is misleadingly named for it is not a true fritillary. Both sexes are similar in appearance, with a wingspan of 2.8-3.4cm (1-1¼in), but the broods can differ, with the second brood tending to have less brown on their upperwings than the first brood. Notice the white markings on the underwings (far right).

LIFE ON WRECKS BENEATH THE SEA

A shipwreck is a disaster at the time when it happens, but the wreckage may last longer than the memory of the loss. Today, the life that springs from the death of a ship–or an aircraft–attracts an increasing number of naturalists and divers.

Right: Few, if any, species live exclusively on wrecks, but some are typical of them. The plumose anemone *Metridium senile* prefers an elevated position and its white, orange or green heads festoon many sunken gangways and railings. This picture of *Metridium* was taken on the wreck of the *Hispanica* in the Sound of Mull.

Below: Soft corals, sponges and a diver on the wreck of the *Glanmire* off St Abb's Head, Scotland.



To man, a shipwreck is a disaster representing tragic loss of life and property, and often pollution of our seas and shores. Historic wrecks such as the *Titanic*, the *Torrey Canyon* and the *Mary Rose* are created by bad luck, human error and war. Time, however, is a great healer and soon many of these lost ships become places of interest and excitement to fishermen, divers and archaeologists.

Many wrecks have long ago been stripped of their valuables by salvagers and others who recover what the sea has taken. The naturalist, however, sees a different value in these wrecks–as sites for an incredible variety of marine life. Living space in the sea is at a premium, and new wrecks provide attachment places and homes for a myriad of animals and plants. In fact, any hard object left in the sea is soon colonized by so-called 'fouling' organisms.

Dangerous coasts Nobody knows exactly how many wrecks there are around the coast of Britain and Ireland. Many are never found, and others are broken up beyond recognition. At a conservative estimate there are at least 250,000 recorded wreck incidents since about the year 1300 AD.

The beautiful rocky coasts of Devon and Cornwall and the west of Ireland and Scotland, exposed to the full fury of Atlantic storms, are notoriously dangerous to shipping. Wrecks of all sorts abound in the Scilly Isles, off the Manacle Rocks in Cornwall, and around Mull in the Hebrides.

Diversity of habitats Sessile (attached) marine plants and animals reproduce and spread by means of floating (or sometimes crawling) larvae and spores, and so what settles on a new wreck partly depends on its position and depth. Wrecks settling on soft sediments provide a sudden and unexpected hard substrate, and quickly become oases of life in otherwise superficially barren areas. The wreck of the *Fort Napier* in the shelter of Loch na Beiste in Skye lies on muddy sand and shell. Its many hanging spars provide a foothold for dead man's fingers (*Alcyonium digitatum*) and the beautiful sea anemones *Sargartia elegans* and *Metridium senile*, other-

wise scarce in this area.

Wrecks settling in rocky areas eventually become almost indistinguishable from their surroundings, although close examination reveals subtle differences. Iron surfaces are sometimes poorly colonized because of the mechanical instability of flaking rust, and so may have less cover than nearby rocks and a predominance of short-lived, rapidly growing species.

A large wreck presents a variety of micro-habitats, and on many wrecks different communities are found at the bow and stern, or from side to side where conditions of current and wave action differ. Seaweeds are restricted to shallow wrecks, and often cover the horizontal top sides, where the light can reach them (although the 'top' may be the side of the ship). Deeper sheltered horizontal surfaces and recesses are often covered in species tolerant of settling silt, such as the sponge *Suberites* and the sea squirt *Ascidiella*.

Surfaces of the wreck Colonial animals are well suited to an attached existence, and many wrecks are covered in 'turfs' of sponges, hydroids, bryozoans and colonial sea-squirts. All these are filter feeders, relying on the current to bring them food particles; they are particularly abundant where such currents are strong. They gain considerable benefit from their elevated position above the sea-bed.

Particular wrecks may be rich in a particular group or species of animal or plant, depending on local conditions. The Dutch cargo ship *Breda* was sunk by German bombers in 1940 and lies in the shelter of Ardmucknish Bay near Oban in Scotland. All 122m (380ft) of her length are still there, and the vertical sides are covered by sea squirts, mainly *Ascidia mentula* and *Ciona intestinalis*, which are typical of sheltered Scottish waters.

The beautiful sea anemone *Protanthea simplex*–only recently discovered by SCUBA divers in British waters–also prefers still waters and adorns the sides of this wreck. The oaten pipes hydroid *Tubularia indivisa* is characteristic of areas of high water movement, and many wrecks in the Sound of Mull and the Menai Straits are dominated by this species.

Hard-shelled borers A few species of specialised animals are not content to live merely on or within a wreck, but burrow into the very fabric itself. The wooden parts of shipwrecks are quickly attacked by the shipworm (*Teredo*) and by piddocks, all bivalve molluscs; and by a small isopod crustacean, the gribble (*Limnoria lignorum*). Henry VIII's now famous wooden warship, the *Mary Rose*, only survived to the present day because when it sank it was rapidly buried by fine silt, thus avoiding the ravages of these creatures.

Abundant fish life Fish seem to be irresistably attracted to wrecks, and anglers have long taken advantage of this. However, only the diver is able to see the beautiful shoals of banded bib (*Trisopterus luscus*) which seem to abound around most wrecks. Solitary larger individuals often prefer the shelter of the dark recesses within the wreck, and many of these lack the banding of the younger fishes. Here too the small poor cod (*Trisopterus minutus*) can be found sheltering. Silvery pollack and saithe, and the ubiquitous ballan wrasse, are

Above: The sea slug *Facelina bostoniensis*, on the wreck of the *Alistair* in Strangford Lough.

Below: A goldsinny in a wreck off Plymouth. A piece of seaweed floats past.

Life on a wreck

This is an artist's impression of life colonizing a wreck. It would exceed the wildest hopes of any diver, whose view would be clouded by floating particles and poorly lit at the best of times. The picture shows the wreckage of a Catalina sea-plane near Millport on the island of Great Cumbrae in the Firth of Clyde. This aircraft was part of a squadron defending the Scottish sea lanes in World War II. It sank in 1941, not as a result of fighting but because of accidental opening of the seacocks, causing the fuselage to flood. It is therefore not a 'grave', and today it is one of the most frequently visited wrecks. To the naturalist, it is an example of a habitat that has not developed a fully stable community, perhaps chiefly because it is subject to winter storms. It is colonized and recolonized by successive different species–such as mussels and barnacles–from year to year, and even at different times of year.

1 *Suberites*, a sponge, under wings.
2 Mussel bed.
3 Yarrell's blenny near crevices.
4 Shoal of pollack in open water.
5 Barnacle patches on upper surfaces.
6 Feather stars out in the open.
7 Common starfishes.
8 Sea urchins.
9 Patch of sea squirts, *Ascidula mentula*.
10 Shoal of poor cod, on bottom or inside.
11 Conger eel occupies larger holes.
12 *Metridium senile*, an anemone: lives in elevated positions.

Above: Ship's timbers riddled with shipworms and encrusted with other molluscs.

Below: Yarrell's blenny on the sea-plane wreck near Millport, Great Cumbrae.

also common residents.

The many holes and crevices in a typical wreck provide ideal homes for conger eels, which lurk in portholes with apparently sinister intent. In spite of their ferocious reputation, congers do not attack divers or swimmers unless provoked by an incautious hand or stick. Smaller holes are inhabited by the tompot blenny (*Parablennius gattorugine*), which peers cheekily out from the safety of its refuge. The tompot is restricted to the south and west coasts, but the equally entertaining Yarrell's blenny (*Chirolophis ascani*) takes its place on the other coasts.

Rich turfs of encrusting species provide shelter and a meal of small worms and crustaceans for the scorpion fish *Taurulus bubalis*. This species is a master of camouflage, and alters its colour to suit the background. The topknot is one of the few species of flatfish living in rocky areas, and small specimens can often be found on wrecks. They, too, merge well into the background. When patches of the pink encrusting seaweed, *Lithothamnion*, are present, the topknot may well display beautiful pink spots for camouflage.

The so-called wreck fish (*Polyprion americanus*) gets its name from the habit of the young fishes of accompanying drifting wreckage, but it is not generally associated with sunken wrecks.

Other predators With their profusion of marine life, wrecks are good hunting grounds for many predators other than fishes. On the wreck of the *James Egon Layne* near Plymouth, cuttlefish can be seen stealthily hunting crabs and small fishes. They catch their prey by a lightning grab with their longest pair of tentacles. Lobsters and edible crabs also find refuges in holes and under timbers, and fishermen often lay pots in the vicinity of a wreck. The rich turfs of sponges and hydroids provide abundant food for the colourful predatory sea slugs.

Changing occupants Wrecks, like rocky areas, can support fairly stable communities of plants and animals. However, such communities may take many years to develop fully. Divers are studying this development by looking at plant and animal communities on wrecks of known age, and making comparisons with the life on the surrounding rocks. The first colonizers of a new wreck are the short-lived, fast-growing species. These are then gradually replaced by longer-lived but slow-growing organisms, which can compete more strongly for space and light.

The kelp *Sacchoriza polyschides* is a very fast-growing annual, and this, along with the sea lettuce, *Ulva lactuca*, which reproduces throughout the year, are often among the first colonizers of shallow wrecks. The perennial kelp forest kelp, *Laminaria hyperborea*, and encrusting animal species, take longer to become established, but eventually take over.

Conservation of wrecks Many wrecks are protected by law because of their historical, archaeological or salvage interests. Some are classified as war graves, and access to these is restricted. In these cases, the marine life gains incidental protection. Some people feel that other wrecks deserve equal protection simply for the rich and varied marine life that they support.

THE QUAIL: A GAME BIRD WITH A PAST

The 'wet my lips!' call of the quail is audible over hundreds of metres, and can be heard in some areas of cereal crops or rough grassland. In most years, however, apart from a few pockets of breeding quail in favoured areas, vast tracts of Britain and Ireland lack this declining species.

The quail is the smallest gamebird in Britain and Ireland, and the only species which is strongly migratory. Just occasionally–the last time was in 1970–there is a year when really large numbers of quail arrive here to settle and breed.

The areas they prefer to settle in are always those with plenty of open fields: dry chalk or limestone regions are the best places to search for them. Even when other parts of the country have few quail, the chalk downs of Wessex and the Chilterns generally hold breeding groups. In some areas the birds may even stay through the winter, but it is clear that the majority winter in Africa, returning here in mid-May, with further influxes in June and possibly July. The loud calling of the first males to arrive may serve to concentrate later arrivals.

The 'breeding young' theory Several theories have been put forward to explain the lateness of the quail's summer arrival. Obviously, a small species of ground feeding bird is very susceptible to cold, but waiting until the end of June seems to be expecting the very worst of British weather. Ringing results and observations in the Mediterranean area are consistent with the idea that adult quail may breed there first and then migrate northwards–to raise a second brood in Britain or Ireland. Even more surprising is the possibility that the young birds reared in the south in

Below: Quail are small, sandy-coloured birds, weighing about 100g (3½oz). The back has a few dark feathers with light streaks giving a mottled and scalloped effect. The underparts are rusty coloured, with two slightly different colour variants–one light, one dark. It is, however, very seldom that birdwatchers are lucky enough to see a quail in the open: most have to be content with hearing its loud and penetrating call.

April or May could accompany their parents northwards and, since they mature very quickly, could breed at seven or eight weeks old! In captivity, quail have been known to breed at the age of only six weeks.

Within ten or 11 days after hatching the young quail are able to flutter about, even though they are not fully grown. This is characteristic of all the game birds, and many records of quail being seen are actually references to fluttering half-grown partridges. The only other bird which is likely to cause confusion is the rare and declining corncrake, which is generally seen in the hay meadows of the far west of Ireland and Scotland.

A bird with a past In the last century, quail were common in Ireland, and in Britain they were much commoner than they are today. At that time many wintered here and they were therefore a resident species. Numbers had fallen heavily by the 1880s, and the habit of overwintering had declined too. More recently, the introduction of much more intensive agriculture has caused a very substantial drop in the number of small weed seeds, the preferred food of quail.

Quail are mentioned in the Bible, and the description of the Children of Israel feasting on them has its counterpart in more recent times. Birds migrating across desert areas may fly very low–even less than a metre high–and so are vulnerable to nets to take them in flight. At other times, for instance immediately after

a sea crossing, the birds come to ground to rest, and can be taken in hand nets. The extent of this slaughter within the present century can be judged from the staggering figure of one million quail exported from Egypt alone in the single year of 1908. Not surprisingly, present-day quail harvests in Egypt are estimated to be considerably lower.

How to map quail Although the birds are difficult to see, it is possible to locate them by surveying an area and listening for their calls. These will be more audible in the night, when other sounds are reduced. The quail's loud, penetrating call, sounding like 'Wet my lips!' is easy to recognise, and carries over long distances. It is almost enough just to cruise along country lanes at night with the car window open; but if you stop systematically for 10 minutes at a time, the result is bound to be better.

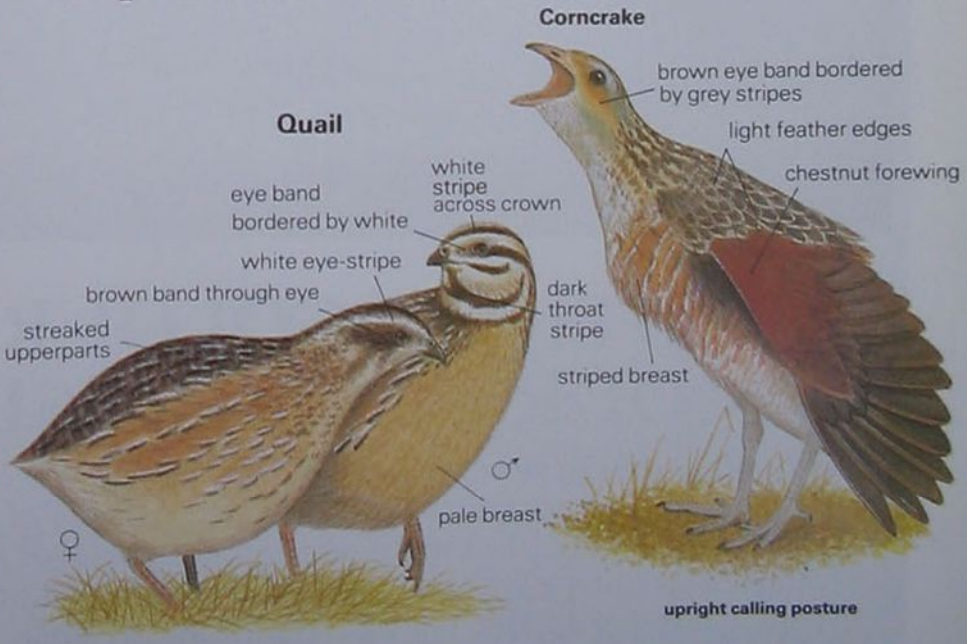
Try to plot the direction from which you hear each calling quail, marking it as a directional line on a piece of tracing paper clipped to a large-scale map. The quail themselves are stationary, so as you travel round marking the lines on the paper, the points at which they cross should represent the position of the birds fairly accurately. Thus you are able to locate the individual members of a local quail population, even though you have probably not approached them closer than a few hundred metres.

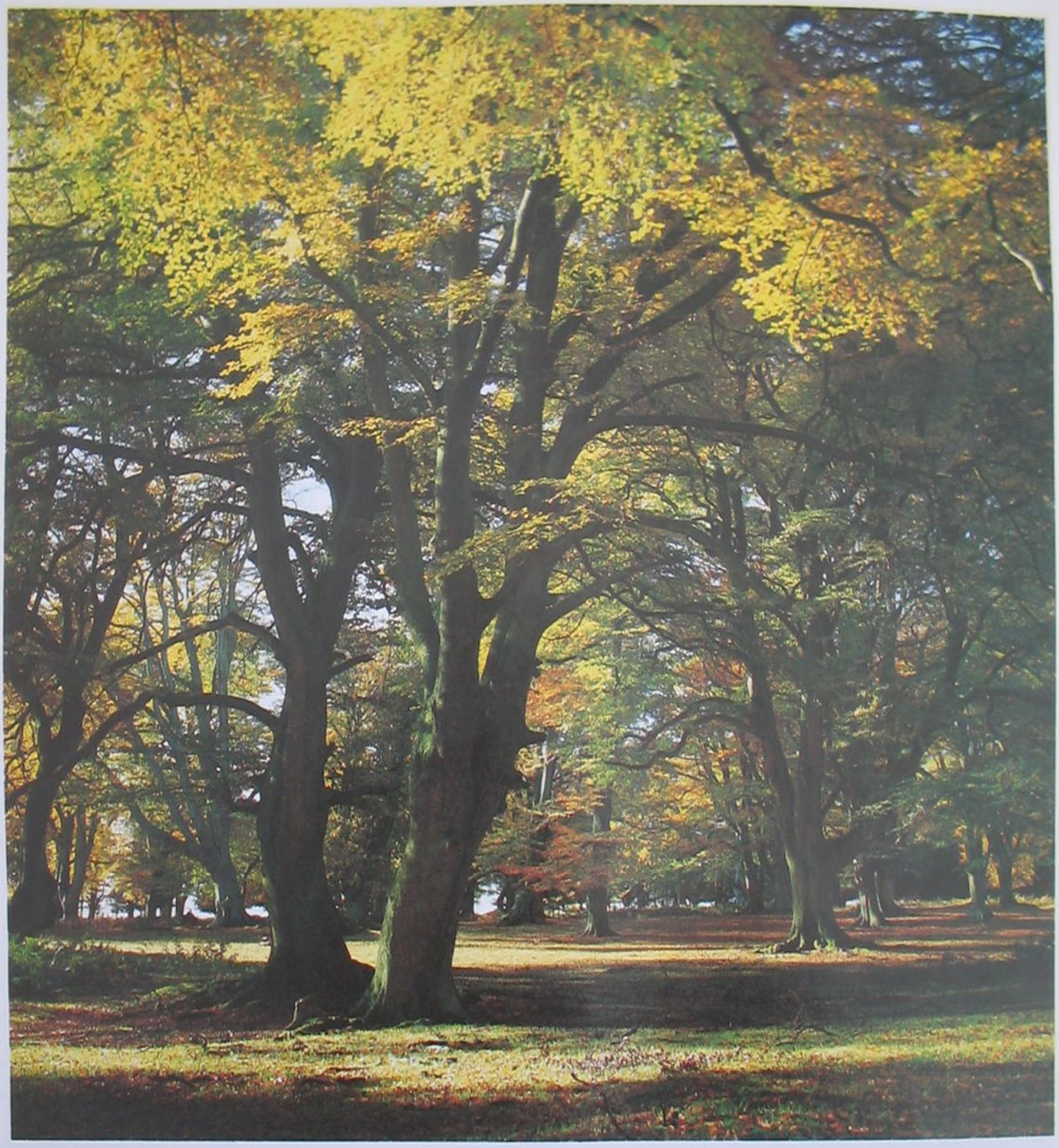
Above: A newly hatched quail chick. The young all hatch together: this has been shown in the laboratory to be due to communication between the chicks while they are still in the egg.

Left: Quail make their nests on the ground, concealing them in tufts of grass.

Quail (*Coturnix coturnix*). Summer visitor to arable fields or rough grassland. Length 18cm (7in).

The quail and the corncrake





AUTUMN COLOURS IN OUR COUNTRYSIDE

As the heat of the summer slowly gives way to the oncoming winter with its frosts and snow, the colours of the countryside shift from the predominant greens of summer foliage and unripe fruits to the yellows, reds and browns of dying leaves, juicy berries and ripe nuts.

Above: No other type of wood takes on such glorious autumn colours as a beechwood–this is Bratley Wood in the New Forest. Throughout this time of year the colour of the leaves gradually deepens from yellow to a rich shade of orange or yellow-brown before the leaves fall. Young beech trees, however, retain their leaves through the winter to protect the new buds from frost.

Just as leaves give summer its overall impression of greenness, so do they contribute most to autumn's hues–and none more so than tree leaves. Leaves are the power houses of a tree, producing simple sugars directly from water and carbon dioxide. At the end of the growing season these small power houses close down and, on most British trees, are cast off. This loss of leaves at a certain time of year (known to us as autumn, but more picturesquely described by the American word 'fall') is due mainly to the fact that leaves encourage the passage of water through the tree. In winter, with water hard to come by from frozen ground and trees generally being less active metabolically, the less they need the better.

The leaves are discarded by the formation of a watertight boundary (the abscission layer) between the branch and the leaf stem. This brittle boundary effectively isolates the leaf from the tree and the break that removes the leaf occurs here. Before this layer has been built up, however, the most obvious sign of the leaf's impending fall, that of colour change, has already taken place. This is the breakdown of chlorophyll, the green compound essential to the leaf's production of sugars. The useful constituent parts of the chlorophyll are ferried away into the main body of the tree, where they are stored until the following spring. As this process goes on, other compounds in the leaf, which were previously masked by the intensity of the chlorophyll's green, become noticeable. The most abundant of these are compounds known as flavenoids, which are yellow, and carotenoids, which are red or orange. It is the presence of these compounds in autumn leaves that is responsible for the colours we associate with this time of the year.

The purpose of the flavenoids and carotenoids is to protect the chlorophyll against too much sunlight, which can cause this complex molecule to break down. The greater the amount of sunlight, the greater the production of flavenoids and carotenoids, and so the finer the autumn colours. This is why northern North America has such spectacular autumn colours: its summers are short but the light intensity is always very high.

Trees in autumn Perhaps the trees with the most brilliant autumn colours are the maples. In Britain our own native field maple has small leaves that turn a delicate shade of reddish-brown or yellow. The introduced Norway maple turns a bright yellow in the autumn, while the sycamore–the most common maple in this country–also ends the season yellow. None of our maples, however, can match the brilliant yellows and reds of two North American species, the red maple and the silver maple. Even in Britain, both these trees can often be seen with leaves that are quite literally scarlet, which makes them popular as ornamental plants in public parks and large gardens.

Outside the maple genus, many cherry trees brighten up the autumn with their leaf colours just as they do the spring with their blossom. Even our own native wild cherry–a common hedgerow species–turns red or pink in the autumn.

Among our native trees, however, by far the most common autumn colours are yellows and browns. On birches and the wych elm the leaves turn yellow before falling. The English elm–a species sadly much reduced after the ravages of Dutch elm disease–has yellow-brown leaves and the endearing habit of shedding them in a short space of time, often only a single day. Our native poplars all have yellow leaves in the autumn, as does the horse chestnut, a tree that adds another dimension to autumn with its rich brown 'conkers'. Beech leaves undergo a gradual change from yellow into a rich shade of orange or yellow-brown before they fall, while oak has golden-brown autumn leaves, which stay on the tree a long time before falling.

Smaller plants In contrast to trees, which by

Above: One of the most vividly coloured shrubs in the autumn is the spindle tree. Throughout the summer it remains an inconspicuous plant with narrow lance-shaped leaves and tiny yellowish-green flowers. Come late summer, however, the fruits begin to develop into coral-pink, four-lobed capsules which split open to reveal bright orange seeds. As the autumn progresses the plant becomes even more colourful as the leaves take on a pinkish hue.

Below: The brilliant yellow autumn colour of a sycamore in the Lake District. Maples (of which the sycamore is one) provide us with some of our most spectacular autumn leaf colours.

virtue of their size remain noticeable whatever the season, many smaller plants–both herbaceous and woody–may catch the eye only in the autumn. Plants that may not have been particularly visible around the middle of summer suddenly reveal their presence a month or so later by the colours of their fruits and seeds. In hedgerow bottoms the cuckoo pint reveals its bright red berries, while the wild dog rose loses its pale pink flowers, which are replaced by the more eye-catching shiny red hips.

Woodlands and hedges on chalk soils are particularly well endowed with autumn decoration, with three climbing plants taking pride of place. The first of these is old man's beard, whose fluffy white seed heads, bereft of any spectacular colour, are still a characteristic sight in autumn hedgerows. The other two species both have red berries and both share the same common name–bryony. White bryony, however, is a member of the cucumber family while black bryony belongs (rather surprisingly) to the yam family. Both plants are far more conspicuous in fruit than they are in flower–despite their names, both bear small white flowers. Black bryony is especially noticeable because it loses its leaves in the autumn, leaving the bare stems hung with bright red berries. Winding through the undergrowth like this, it resembles a string of beads.

Chalkland fruits Several bushes and small trees of chalk scrubland have distinctive fruits. The common buckthorn, for example, which is a thorny shrub growing to a height of about 2½-5m (8-15ft) tall, has clusters of black berries, which contrast very effectively with its yellow or yellow-brown oval leaves. These berries have a very strong purging effect; hence its alternative common name of purging buckthorn.

Above: These bright red berries of the wayfaring tree are not yet ripe. They will slowly darken to become black at maturity, while the leaves simultaneously take on their reddish autumn hue.

Below: Horse chestnut leaves showing the complete range of colours from green through yellow to red and brown as green chlorophyll in the leaf cells is broken down, allowing the yellow and red flavenoids and carotenoids to show through.

The small wayfaring tree, which despite its name is often a bush, is a distinctive plant in both spring and autumn, its early heads of white flowers being replaced by red berries later in the year. Another very handsome small tree, the whitebeam, looks attractive from spring through to autumn with the silvery-white undersides to its leaves (hence its common name) and the lovely heads of white flowers that appear in May and June. Like the wayfaring tree it, too, produces heads of red berries in the autumn, though whitebeam berries tend to be round whereas those of the wayfaring tree are more oval and they also turn black later in the season.

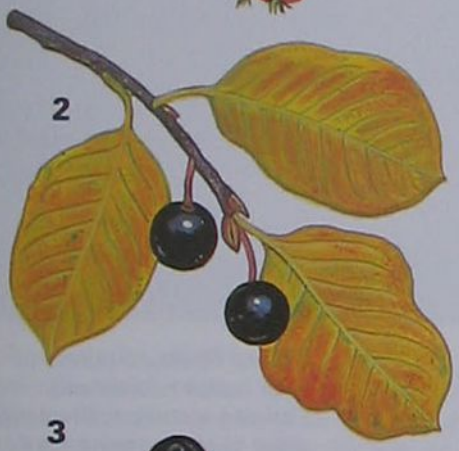
Elder is another tree or large shrub that shows well in the autumn, its heads of blue-black berries attracting both birds and winemakers alike.

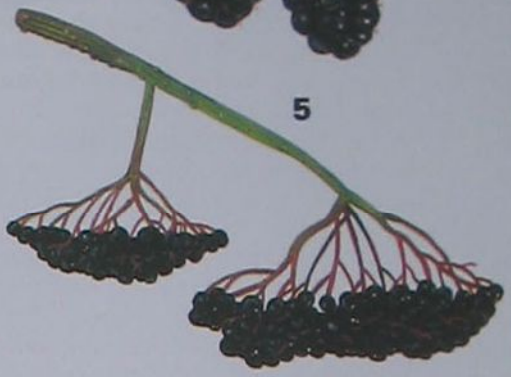
Spindle and dogwood The two most colourful shrubs of chalkland in the autumn are undoubtedly the spindle tree and dogwood. The spindle tree remains an insignificant plant for much of the year until the late summer when its fruits begin to form. These are coral-pink, four-lobed capsules and contain orange seeds.

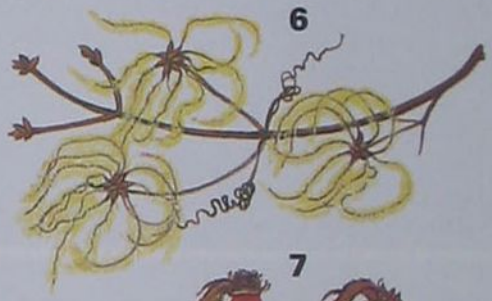
Dogwood is slightly more conspicuous than the spindle tree. It is a small shrub with oval leaves that produces small creamy-white flowers in early summer. These develop into black berries by September, and towards the end of autumn the leaves turn crimson and the shoots blood-red. The shoots stay this colour after the leaves drop, and remain so until they are hidden by new growth next spring.

As the colour balance shifts from the greens of summer and its brightly coloured flowers to the more subtle yellows and browns of dying leaves, there are still splashes of eye-catching colour to be seen in the abundance of fruits.

Autumn colours







Plants with colourful leaves and fruits:
1 Whitebeam (*Sorbus aria*). Chalkland tree with yellow-brown leaves and red berries.
2 Alder buckthorn (*Frangula alnus*). Shrub of damp woodland with yellow autumn leaves and black berries.
3 Dogwood (*Cornus sanguinea*). A striking chalkland shrub with reddish leaves and shoots, and black berries.

Plants with attractive fruits:
4 Blackberry (*Rubus fruticosus*). A common climbing plant of hedgerows and woods with black fruits.
5 Elder (*Sambucus nigra*). Shrub or small tree with heads of black berries.
6 Old man's beard or **traveller's joy** (*Clematis vitalba*). Climbing plant with white fruiting heads.
7 Dog rose (*Rosa canina*). A familiar climbing plant with red hips.
8 Cuckoo pint (*Arum maculatum*). Plant of chalkland with upright heads of red berries.
9 Black bryony (*Tamus communis*). Red-fruited climbing plant of well-drained soils.

Trees with attractive leaves:
10 Beech (*Fagus sylvatica*). Orange-brown leaves.
11 Wych elm (*Ulmus glabra*). Yellow leaves.
12 Silver birch (*Betula pendula*). Yellow leaves.
13 Japanese cherry (*Prunus serrulata*). Golden-pink leaves.
14 Silver maple (*Acer saccharinum*). Scarlet leaves.

PROBLEMS FACING OUR NATIVE PONIES

The British Isles are unique in having nine distinct breeds of native ponies. Known collectively as the Mountain and Moorland breeds because of their native habitats, they are part of our national heritage. What is their future, now that they are mainly 'pleasure' rather than working animals?

Above: Shetland ponies in their native habitat and (below) a stallion. Shetlands seem to retain their native characteristics even when bred far from their native heath. This may be explained by the relative lack of outside blood involved during their development–in marked contrast to every other breed except the Exmoors. Southern-bred Shetlands soon grow thick coats if they return home.

For hundreds of years the Mountain and Moorland ponies of the British Isles were indispensable, playing a vital role in farming, draught work and transport. It is only during the last 50 years or so, since general mechanisation, that they have come to be used primarily as 'pleasure' animals, to be ridden, driven or shown in hand in the many equestrian activities up and down the country.

As a result, the native breeds are subjected to far more human interference and influence than ever before. The most important change is that more and more ponies are now being bred on studs away from their native habitats, in environments quite different from those of their ancestors. This may lead to changes in the characteristics of some ponies, which in turn leads to concern that the true 'native'

features of the breeds are being lost.

True native features The 'native' features have evolved over the centuries largely in response to the harsh environment of the mountain and moorland habitat. Although each of our nine breeds has its own distinctive appearance, all have certain characteristics in common.

For instance, all have thick manes, tails and forelocks which protect vital structures from extreme weather and help to channel away rain from the body. Such breeds as the Shetlands and Highlands, living in the harshest habitats, have the most profuse growth. All breeds grow thick, insulating winter coats.

Native ponies have proportionately larger heads than horses, allowing for a greater nasal passage area so that cold air has a chance to warm before entering the lungs–a necessary heat-preservation device. Good, strong jaws are also essential to cope with the rough herbage–heather, holly and gorse–that makes up a significant part of most diets.

The overall outline of native ponies is compact and sturdy-looking, with proportions such that the depth of the body equals the length of the leg, and the length of the body exceeds the height. The short, strong legs are necessary to travel safely over the rugged terrain of the native heaths. The action (movement) of the ponies is also distinctive. There should be a certain amount of elevation of the knee, thus allowing the feet to clear the ground and move easily through the herbage.

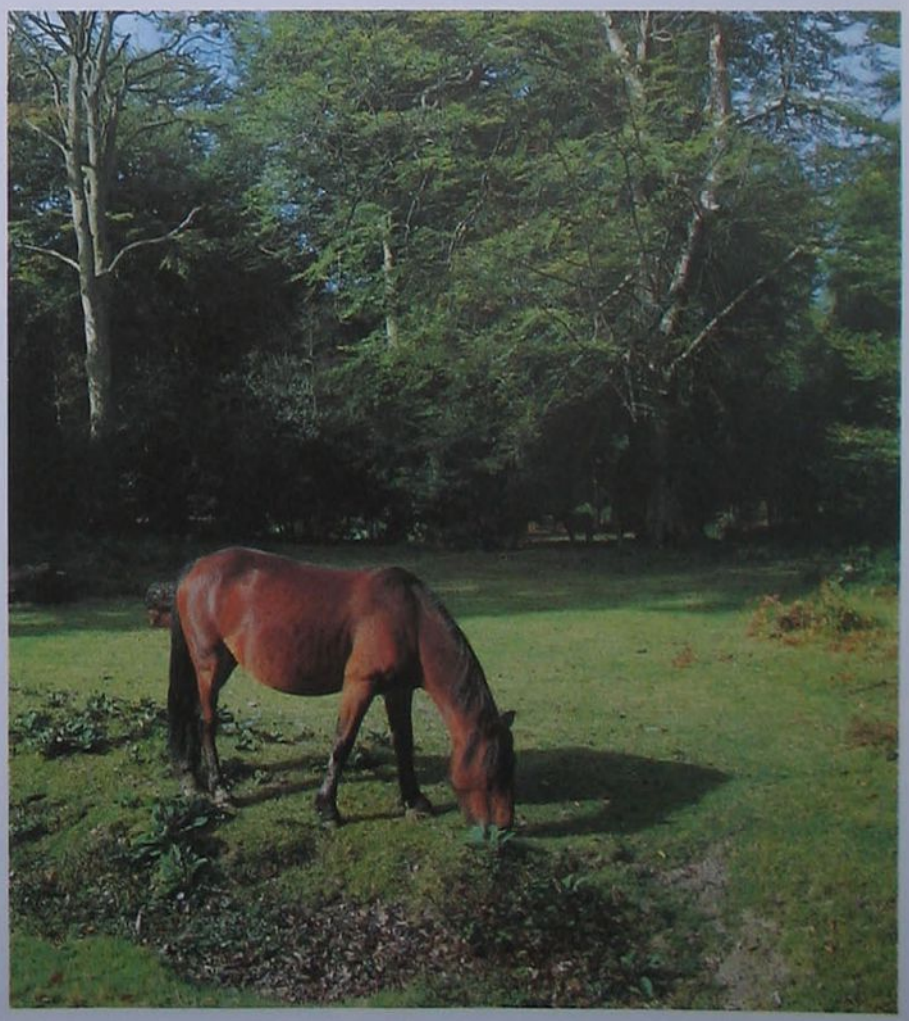
New native types Since the widespread establishment of native pony studs here and abroad, variations have begun to occur in the type of pony being bred. Some changes are unavoidable: a less rigorous environment and the richer food of lowland areas has the same effect on many ponies as (to quote one authority) 'growing tomatoes on a manure heap': they grow rapidly but tend to become taller and more spindly. This tallness is almost always achieved by longer legs, but they do not become correspondingly thicker, particularly below the knee. This leads to lightness of bone, and a consequent loss of the strength and weight-carrying ability which is such a feature of the breeds. Often the longer leg is not matched by an increase in the depth of the body, so the overall body ratio typical of native ponies is upset. There is a natural tendency too for winter coats and manes and tails to grow less profusely as they are not needed in the more temperate climates.

Of more concern to many native pony enthusiasts are the deliberate breeding policies adopted by some stud owners to try to refine their animals for show ring success. In show classes the standard of perfection required by judges is based on their idea of the perfect Thoroughbred horse–long of leg (for speed), small of head (for extreme elegance), and a much lower action with a pointed toe (often described as 'daisy-cutting'). These are all highly desirable points in a racehorse bred for speed and little else, or for a decorative hack, but disastrous for a native pony trying to exist in its native habitat.

More importantly, perhaps, these refined features are seen in children's riding ponies –bred for the show ring and evolved by crossing native ponies with small Thorough-

Above: A typical Highland filly grazing.

Below: There are many New Forest ponies but because of past breeding policies they are not necessarily all of the right type.



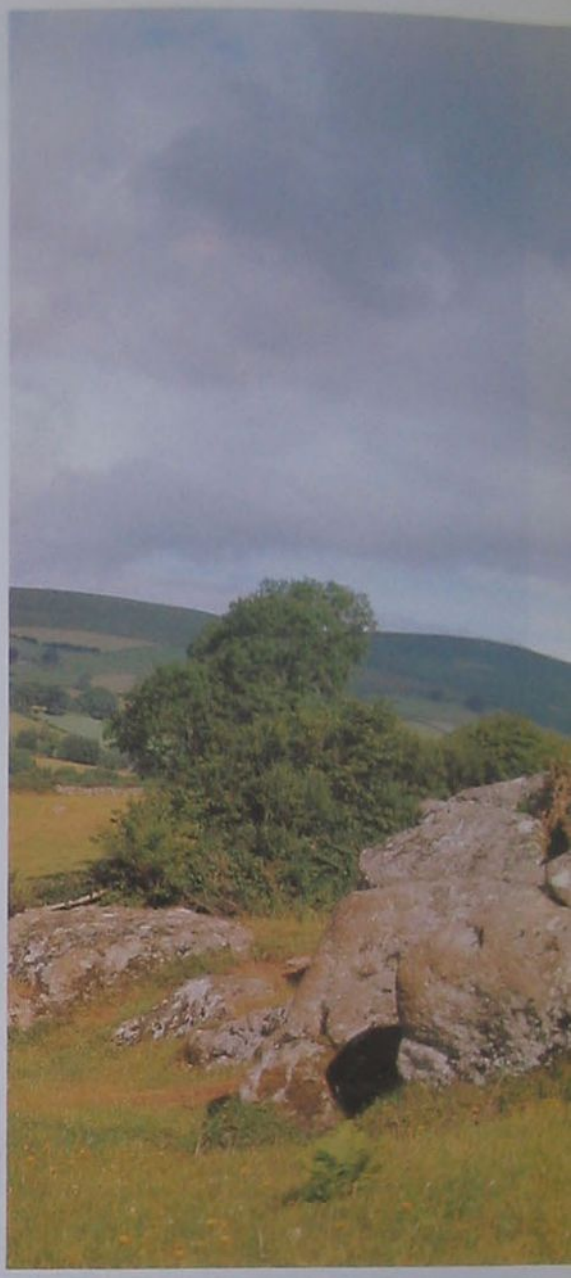
breds or Arabs, with additional refinement obtained by putting the progeny of that cross back to a Thoroughbred. Sometimes described as 'beautiful but useless', these ponies are not as rugged as native ponies and are often highly strung and difficult to manage. However they are in great demand and fetch high prices.

There has been a tendency recently to place in native pony classes animals which show many riding pony characteristics–exceedingly small heads, lack of bone and substance, and a low, daisy-cutting action. Whether these ponies are attractive in appearance is arguable; what cannot be disputed is that they do not exhibit true native characteristics, but because they are often successful in the show ring, stud owners tend to breed them.

If the aim is to breed a pleasant-looking pony that works well and can be ridden easily then this development is not important. If, on the other hand, the aim is to breed true Mountain and Moorland ponies, preserving their characteristics of extreme hardiness, good temperament and weight-carrying ability for which they are world-famous, then this new trend is to be regretted. If carried to its logical conclusion it means that in time Britain could lose its nine distinctive breeds and be left with a single breed of native pony, all individuals looking as alike as peas in a pod. Even now it can be quite difficult to distinguish one breed from the other.

What is to be done? Some of the problems arise through breeding away from the native environment. This must be continued if the native breeds are to survive in any numbers. But some of the undesirable effects can be counter-balanced by breeders returning to the native mountain and moorland environment from time to time to buy colts and fillies actually bred there and showing the true native features. These can be incorporated into the stud blood lines, and so re-infuse them with hardier blood. A number of the best breeders do this regularly.

Right: Dartmoor ponies in their native habitat, and (below right) a stud bred pony. The problems of Dartmoors are similar to those of all British native ponies: there are relatively few pure-breds still turned out on the Moor although there is at least one breeder who is trying to establish a herd to run-out. The part-bred ponies which live on the Moor are frequently the centre of controversy because of the appalling condition of some of them during the winters. Like many native ponies, they have lost the hardy characteristics which once made them well-adapted to live in a harsh environment.



Below: A champion Exmoor colt. The Exmoors have been in difficulties in recent years and there are now only three small herds still running out on the Moor, and only three stallion lines remaining. However, the Exmoor National Parks Committee has set up a small herd, and the National Trust is taking filly foals to rear on a local farm and then turn out again on the Moor with a suitable stallion.

However, this is not quite as easy as it sounds, depending as it does on the availability of ponies of sufficient quality in the native habitats. This varies with the breed. In the New Forest, for instance, there are plenty of ponies, but because of past breeding policies these are not necessarily all of the right type. Here the Countryside Commission has introduced a scheme whereby the New Forest Commoners, who own the ponies, will have their marking fees (grazing fees) paid for suitable mares, to encourage the retention of such ponies on the Forest. The subsidised mares will then be studied to establish the most hardy lines and the most suitable will be retained as a breeding reservoir.

Many Forest and Shetland ponies are sold to the meat trade. Distasteful though it may seem, unless breeders can sell their surplus stock during the present glut on the pleasure

pony market, they will stop breeding, with disastrous results for them and for the studs as well. So a viable meat trade is essential.

The other breeds are suffering too. The Exmoors particularly have been in serious difficulties in recent years. Of the Welsh breeds, the Section B or Welsh Ponies are the most seriously affected as they, of all the nine breeds, have evolved furthest from their native characteristics. There are now few, if any, of these ponies on the Welsh hills. The Fells, Dales and Highlands have suffered rather less than the others, although a study has been instigated to try to compare the amount of bone in Dales ponies bred away from the native habitat with that of ponies bred in the north of England.

Overall the picture in the native habitats is not wholly reassuring. Many people wish that as much attention was being devoted to breeding good ponies as there is lavished on the studs, so that a thriving population would be available to provide a breeding reservoir to which stud owners can frequently return.

BRITAIN'S TROPICAL GRASSES

Of Britain's 150 or so types of grass, a few are closely related to exotic, even tropical, species such as bamboo, rice and pampas grass.

Islands usually have a more restricted range of species than the adjacent mainland, and the British Isles are no exception. Britain has fewer species than Continental Europe, and Ireland fewer than Britain. As far as grasses are concerned the British Isles have only about one in ten of the European species, and these are dominated by four main genera: the meadow-grasses (*Poa* spp.), fescues (*Festuca* spp.), bents (*Agrostis* spp.) and bromes (*Bromus* spp.). All these groups are notoriously difficult to identify. Yet within this relatively dull assortment of grasses there are a few with some unexpectedly exotic connections.

Grass groups The grass family–known to botanists as Gramineae or Poaceae–can be divided into five sub-families (all with seemingly jaw-breaking names). One of these, the Panicoideae, is a highly advanced group of tropical grasses. No British grasses belong to this group; most are found in another sub-family, the Pooideae, including all four genera mentioned above. But a few British grasses are found scattered among the remaining sub-families. These sub-families are the Arundinoideae, a group of grasses with a simple structure found in the sub-tropics and warm temperate regions; the Bambusoideae, which includes the bamboos and displays many primitive features; and the Chloridoideae, which are mainly tropical grasses of savannahs and desserts.

Bamboo relative One such grass is a member of the bamboo group. This is cut-grass, a plant that grows on the margins of streams and ditches in a few parts of southern England. It is usually overlooked because, except in the warmest weather, its flower heads remain enclosed in the leaf-sheath.

Even when the flower heads do appear, there is nothing very remarkable about them. In a typical grass, each minute flower is enclosed in two chaffy scales–the lemma and palea. Flower, lemma and palea constitute a floret, and there may be one or more florets in each spikelet, which is enclosed in two further scales called glumes. In a spikelet of cut-grass there are no glumes and there is only one

Above: A stand of common reed (*Phragmites australis*). The stems of this grass–the largest in Britain–are tough enough to be used for thatching. Its South American relative, *Gynerium sagittatum*, however, is so strong that its stems are used to build the walls of huts.

Above right: Common reed flowers between August and October.

Right: Almost all the British species of grass are found in one sub-family, the Pooideae. But three other sub-families also contain British grasses, and these are illustrated here. Apart from cut-grass all these grasses with tropical affinities share, by a strange coincidence, a common feature. In most British grasses the ligule (the structure at the junction of the leaf and sheath) consists of a membrane. In grasses with tropical affinities the ligule consists of a line of hairs.

floret, the lemma and palea of which are leathery and very rough to the touch.

Cut-grass is named after its sharp, saw-edged leaves, but it was only when scientists looked inside the leaves that they realised the similarity between cut-grass and rice which, in turn, is related to bamboo, primarily because of the anatomical structure of the leaves.

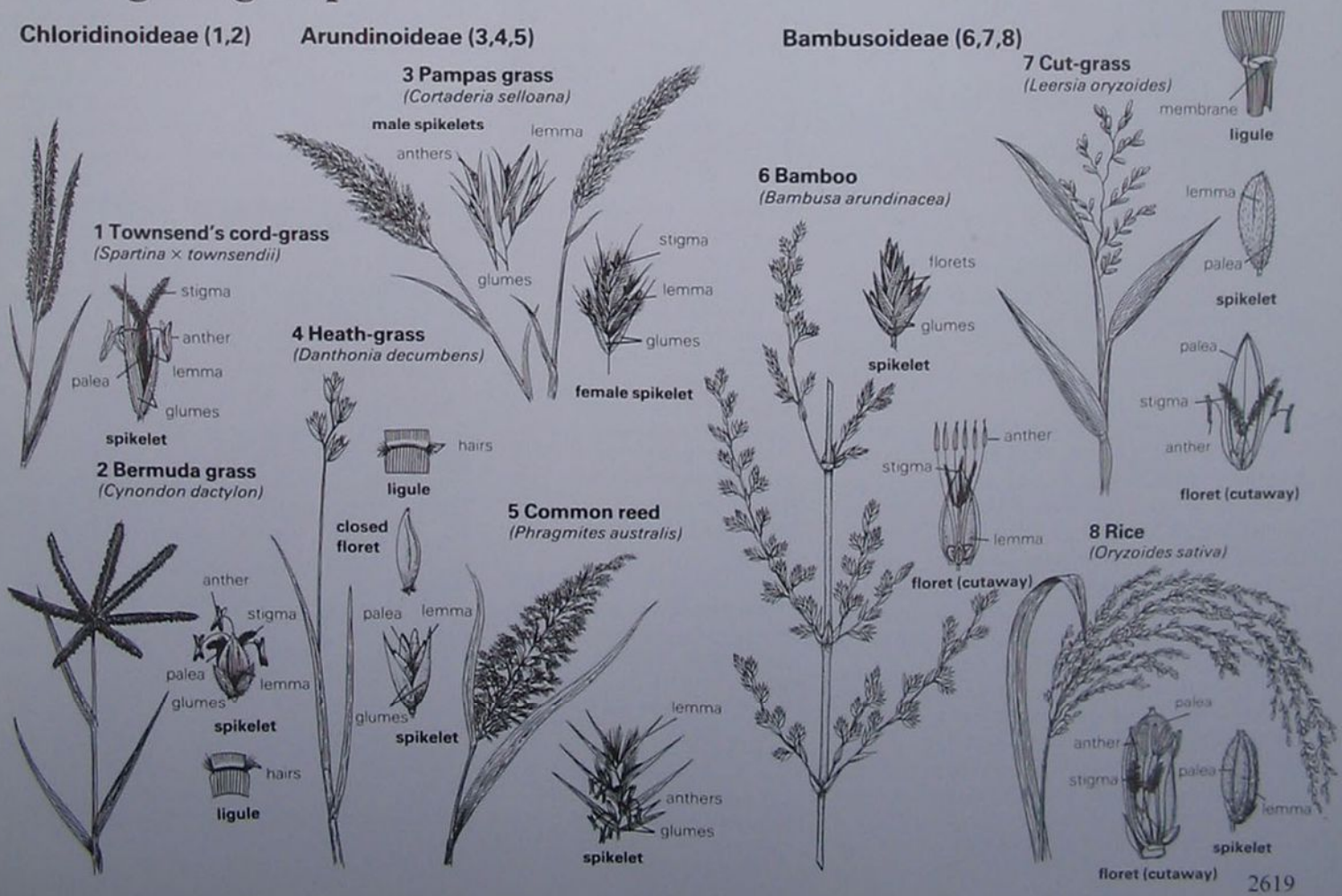
Cut-grass and rice are known as bamboo-allies, a strange collection of oddities, some of which have such unusual features as underground inflorescences, broad leaves with net veining (rather than the parallel veining typical of most grasses) and even insect pollination.

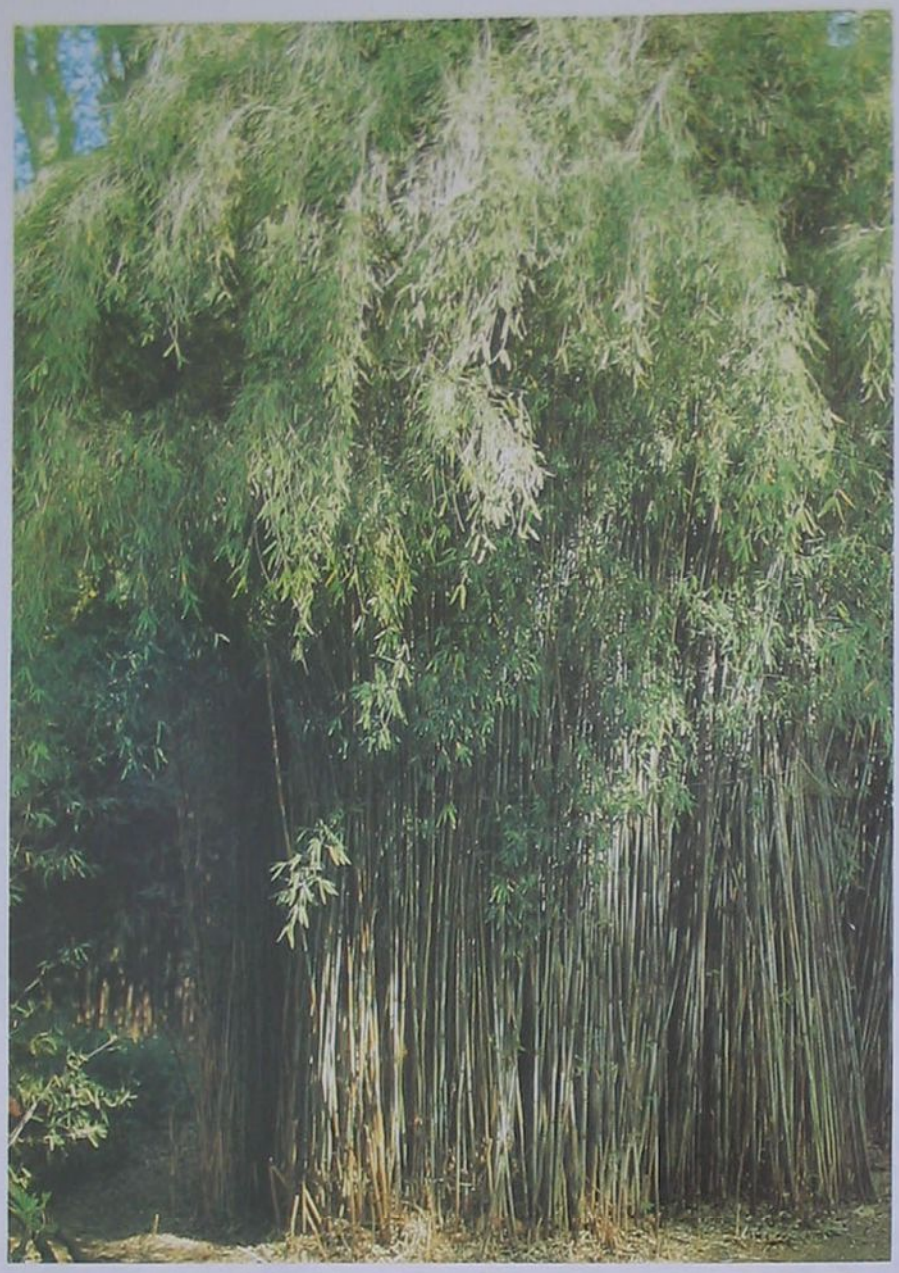
Moor and heath grasses Another sub-family of grasses with British representatives is the Arundinoideae. This sub-family can be further sub-divided into two groups. The first group consists of small, tufted grasses such as purple moor-grass and heath-grass, both British species.

Purple moor-grass is a variable plant looking somewhat like a fescue, but it does have two very odd features. It has deciduous leaves which are shed from the sheaths in winter–a feature unique among British grasses–and the tuft of leaves at the base is divided into two levels, the stem in between becoming swollen with food reserves.

Heath-grass is an isolated member of a genus (*Danthonia*) that reaches its greatest diversity in southern Africa and Australasia.

Three grass groups





Heath-grass is the only British member of this genus. It is a rather small plant 10-60cm (4-24in) tall, with a few large spikelets borne in a tight head. The spikelets are unusual among British grasses in that they are self-pollinating without opening (although, when growing on wet ground, the plant may show more normal behaviour).

Reeds and pampas grass The second group of arundinoids is represented in Britain by the common reed. This species is a very close relative of the European giant reed, whose stems are used to make reeds for clarinets and oboes, and is common over most of the British Isles. Its most distinctive characteristic apart from its tall stems (which may be up to 2m/6ft tall) is the large inflorescence looking like a purple and white feather-duster.

Another plant with a large feathery inflorescence, but with quite a different habit, is pampas grass. This plant is widely grown in Britain as an ornamental, and forms huge tussocks with long, saw-edged leaves. Yet, despite its different manner of growth, it is closely related to our own common reed.

Pampas grass is a South American plant, but it does not actually grow in the grassland areas known as the pampas. Instead, it inhabits rocky gullies and dry stream-beds high up in the Andes Mountains. East of the Andes, along rivers penetrating the Amazonian rain forest, is found an even closer relative of the common reed than pampas grass. This is *Gynerium sagittatum*, the world's largest herbaceous grass at 10m (33ft).

Bermuda and cord-grass The final sub-family of grasses with British representatives is the Chloridoideae, a group of tropical and sub-tropical species found in savannahs, deserts and other dry, hostile, marginal areas. The main body of chloridoids penetrates no further north than the Mediterranean region, but one species is found in a few places in southern England. This is Bermuda grass, a plant that some people think is native to this country but was more likely introduced here by the Romans. It is a low, sward-forming perennial with runners, both on the surface (stolons) and underground (rhizomes).

The most unusual feature of Bermuda grass is its spikelets. These are one-flowered, stalkless and arranged in two rows along a slightly curved stalk called the axis. Some other British grasses, such as rye-grass, have these so-called spikes, but only in Bermuda grass are there several borne at the very tip of the stem.

In temperate parts of the world a group of chloridoid grasses have established themselves in an environment no less harsh than a desert–saltmarshes. A British member of this group is cord-grass. Like Bermuda grass, this plant has one-flowered spikelets borne in spikes, but they differ in one important respect: instead of the spikes being borne at the tip of the stem they are arranged along it.

Above: Bamboos are the most highly specialised of all grasses, having given up the herbaceous habit to compete on equal terms with trees and shrubs. In hot climates bamboos can grow to a height of 35m (120ft). In Britain one of the most commonly cultivated species is *Arundinaria nitida*, a stand of which is shown here. This species grows to a height of about 5m (16ft) in this country.

Right: Though superficially similar to the fescues, purple moor-grass (*Molinia caerulea*) can be distinguished by its lemma, which has three veins, not the five possessed by most fescues and most other grasses. It flowers from July to September.

HARDY MOUNTAIN SAXIFRAGES

Delicate though they may look, saxifrages are hardy plants well adapted to the rigours of their native habitats on exposed mountains.

In Britain the saxifrage family (Saxifragaceae) is represented by two groups of plants. The largest is the genus *Saxifraga*, after which the family is named, but there are also two species in another genus, *Chrysoplenium*.

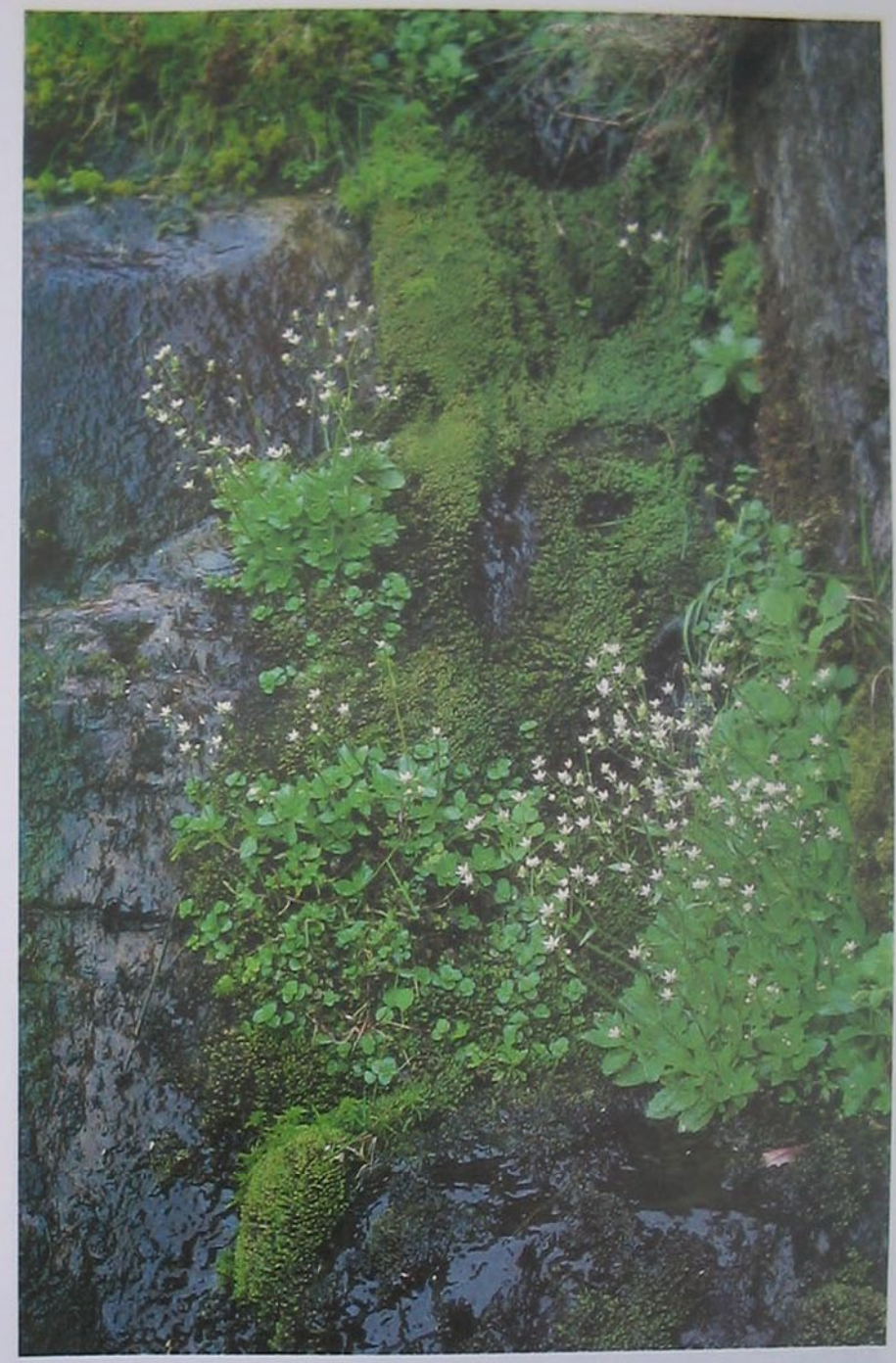
Saxifrages are predominantly mountain plants, the Highlands of Scotland being the best place in Britain to see them. Many have very restricted distributions; the drooping saxifrage, for example, is now nearly extinct in this country and survives only on the summit of Ben Lawers in Scotland. Others, such as the dovedale moss (which, despite its name, is a saxifrage), are more common and not confined just to the highest altitudes but may be found lower down–to the delight of both naturalist and walker alike.

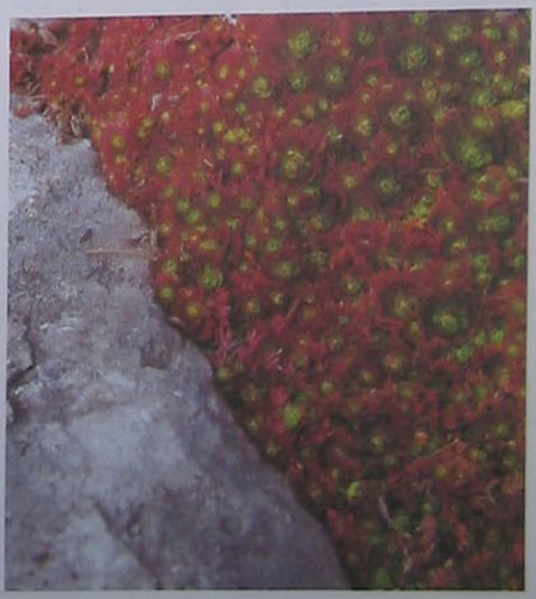
Rosettes and cushions Britain's saxifrages can be divided into two types according to their manner of growth: those that form rosettes and those that form cushions. The rosette types have a compact rosette of leaves spreading from the top of a very short stem, or stock as it is more usually known. The leaves are commonly pressed close to the ground.

The cushion saxifrages, on the other hand, consist of a great many short stems arising from the main root. These stems, in turn, branch again to produce more slender stems, which are covered with tufts of small leafy shoots. The whole structure is usually very compact and low-growing, seldom rising more than a few centimetres above the ground and giving the appearance of a leafy cushion–for the branches are usually hidden from view by the densely packed tufts of leaves.

Both the rosette and the cushion habits are adaptations to difficult conditions often experienced on mountain summits and exposed, wind-swept ledges. The low growth habit protects the plants from fierce winds which, apart from physically damaging the plants, would have a serious drying-out effect by causing water to evaporate too quickly from the leaf surface.

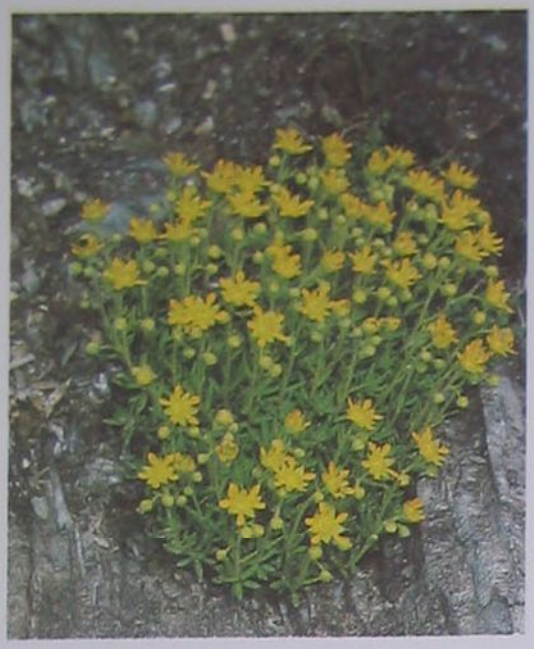
Drought, indeed, is one of the major problems facing saxifrages living at high altitudes. For many months of the year the soil is covered with a deep layer of snow, and





Above: Starry saxifrage (*Saxifraga stellaris*), a rosette-forming species common on damp ground–particularly springs and stream sides–in many mountainous regions. The leaves of this plant are held semi-erect above the ground, probably to prevent them becoming waterlogged.

Right: Dovedale moss (*Saxifraga hypnoides*) overwinters as a cushion of tightly packed leaves, producing upright heads of white flowers from May to July. Also known as mossy saxifrage, it is one of our more widespread members of this group.



London Pride

Many saxifrages make excellent garden plants, one of the most commonly grown being a hybrid usually called 'London Pride', a reference to its ability to thrive in London's once-smoggy atmosphere. Occasionally escaping and becoming naturalised, this hybrid is a cross between two species, one being *S. spathularis*, an Irish saxifrage sometimes known as St Patrick's cabbage, and *S. umbrosa*, a saxifrage native to the central and western parts of the Pyrenees Mountains.

streams and soil-water may be frozen solid. In such conditions it may not be possible for a saxifrage to take up enough water through the roots to compensate for water loss through the leaves. Furthermore, summer comes late to these areas, and it may be as late as June before the last traces of snow have disappeared from the tops of the highest mountains. On sheltered slopes it may not clear at all. Also, much of the rain falling on a mountain is lost down the slope, and the stony soil high up receives very little. So, although the rainfall is usually high in mountain areas, the soil itself can often be dry.

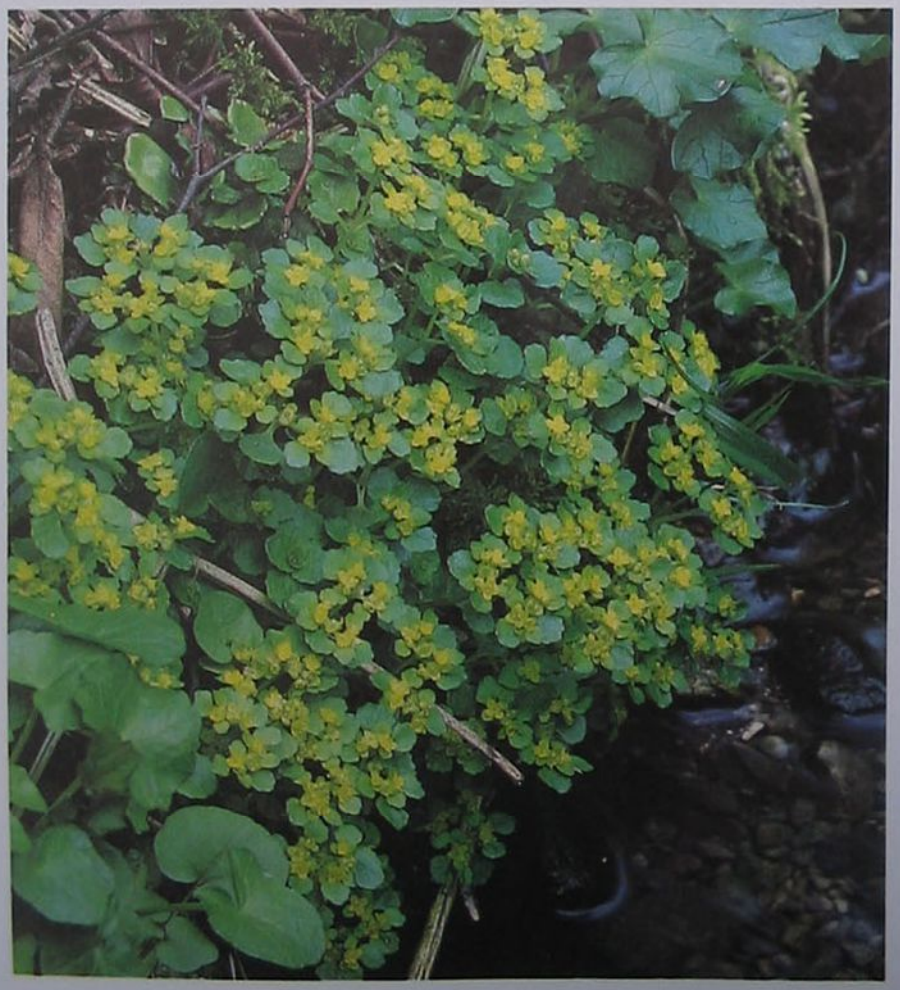
Purple saxifrage One of the loveliest cushion-forming species is the purple saxifrage, whose rosy-purple flowers first appear during April in Scotland, and February and March in north Wales. This is often before the snows have melted away. The flowers of this species – in common with those of others in the genus *Saxifraga* – have five petals and five sepals. Within this outer ring are ten stamens, five of them opposite the petals and five alternating. In the centre are two styles. The flowers secrete nectar to attract flies and small bees.

The fruit of a saxifrage consists of a capsule with two diverging horns on top – these are the remnants of the flower's two styles. When ripe the fruit splits open along the top to release the seeds, which are gradually shaken out as the capsule is blown in the wind.

Above left: Yellow mountain saxifrage (*S. azoides*) grows on wet stony areas and by stream sides.

Right: The flowers and ripening fruit capsule of dovedale moss.

Below: Opposite-leaved golden saxifrage overhanging a stream.



The leaves of the purple saxifrage exhibit an interesting feature – their tips have a special gland called a hydathode which regulates the transpiration of water from the leaf. On dry days, when the rate of evaporation through this gland is high, the tissues immediately around the gland secrete lime. The lime is dissolved by the water in the gland, and the water evaporates to leave the lime behind as a deposit. This deposit builds up and the gland is eventually shut off, preventing any more water from escaping. During the night, or in colder weather when the rate of transpiration is low, some of the lime dissolves and the gland is opened up again.

Tufted saxifrage Another cushion-forming species, but one much rarer than the purple saxifrage, is the tufted saxifrage. This species grows only on the highest summits. It has small, usually three-lobed leaves which lack the lime-producing glands of the purple species. Its flowers are whitish and are borne,

one or two to a stem, from May to July.

The flower stems of tufted saxifrage are covered with short sticky hairs to prevent crawling insects from climbing up and stealing the nectar without pollinating the flower. In practice, although the plant produces abundant nectar, it is often not visited by pollinating insects and pollinates itself instead.

Two rosetted species A typical rosette saxifrage is the alpine saxifrage. The erect flowering stems bear three to twelve flowers clustered into a dense head. The petals are greenish-white but the surrounding sepals are often purplish, giving colour to the flower as a whole. At the base of the flowering stems is a rosette of leathery, egg-shaped leaves with toothed margins.

A much more common rosetted species is the starry saxifrage, found on many mountains in Scotland, Wales and Ireland. Its leaves have a thinner texture than the alpine species and, instead of being held close to the ground, are semi-erect. The flowers are pure white with two small yellow spots near the base of each petal. They are borne on leafless stems in heads of 12 or more.

Bulbil bearers Because the growing season is very short in mountainous areas, saxifrages are sometimes not able to complete their reproductive cycle and disperse their seeds before the onset of winter. Instead they may rely on vegetative reproduction, often by producing miniature bulb-like structures called bulbils.

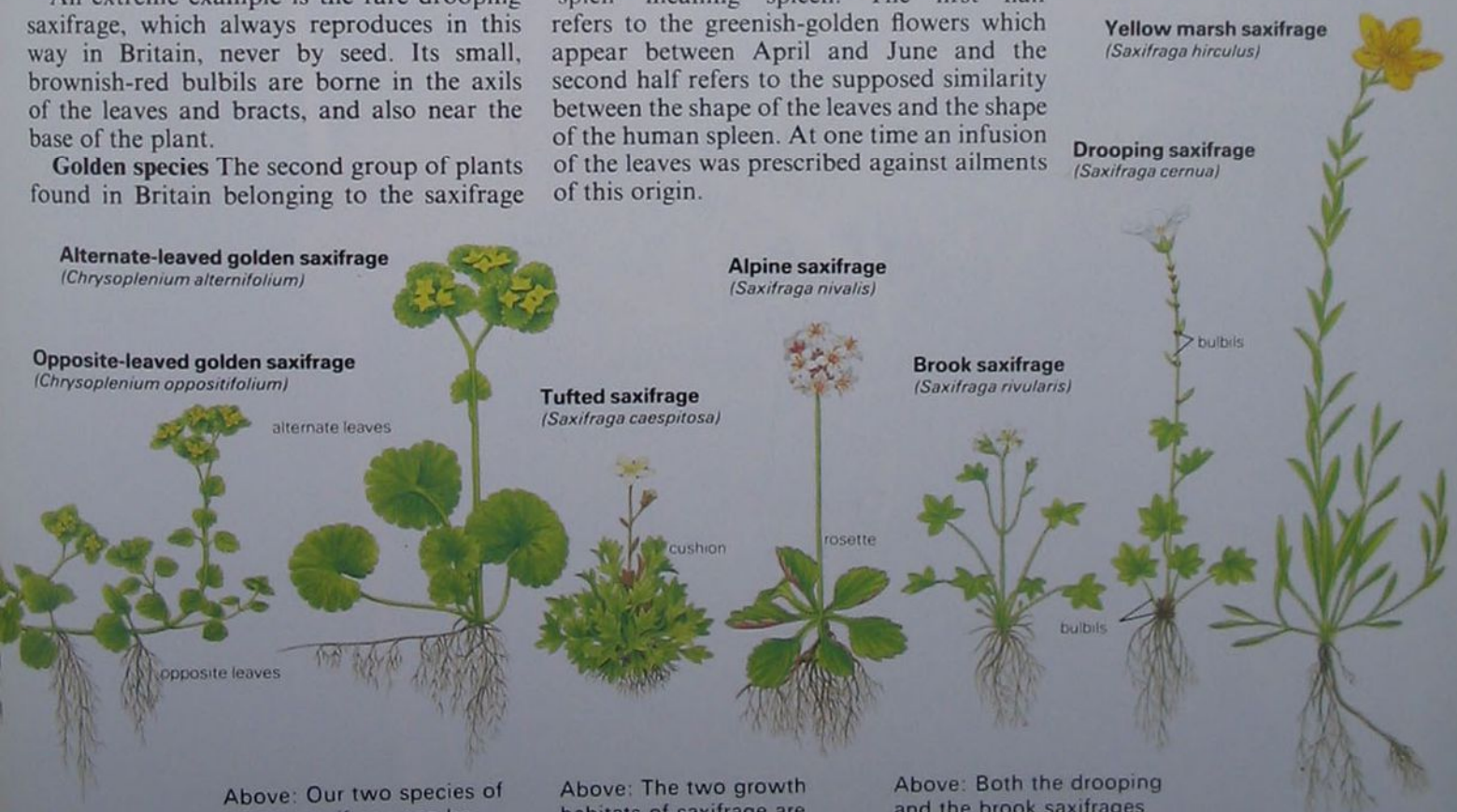
An extreme example is the rare drooping saxifrage, which always reproduces in this way in Britain, never by seed. Its small, brownish-red bulbils are borne in the axils of the leaves and bracts, and also near the base of the plant.

Golden species The second group of plants found in Britain belonging to the saxifrage family are different enough from the main body of species to be placed in a separate genus, *Chrysoplenium*. Commonly known as golden saxifrages, they differ from the true saxifrages in having flowers with no petals and usually fewer sepals and stamens.

Two species grow in Britain, the opposite-leaved and the alternate-leaved golden saxifrages. Both grow in wet places in woods, and along stream-sides, springs and wet rocks.

Their botanical name comes from two Greek words–'chrysos' meaning gold and 'splen' meaning spleen. The first half refers to the greenish-golden flowers which appear between April and June and the second half refers to the supposed similarity between the shape of the leaves and the shape of the human spleen. At one time an infusion of the leaves was prescribed against ailments of this origin.

Above: The purple saxifrage (*Saxifraga oppositifolia*) is one of the loveliest species, appearing early in the year, often before the snow has cleared away. It grows on damp rocks and soil-covered ledges of mountain cliffs, where its long roots penetrate far down through cracks and fissures in search of water.



Above: Our two species of golden saxifrage can be told apart at a glance just by looking at the way the leaves are arranged.

Above: The two growth habitats of saxifrage are cushion, as in the tufted saxifrage, and rosette, as in the alpine saxifrage.

Above: Both the drooping and the brook saxifrages reproduce by bulbils, the drooping saxifrage exclusively so in Britain.

HARVEST MICE ARE HERE AFTER ALL

As long ago as the 1930s people were suggesting that the harvest mouse was in imminent danger of extinction, and the boom in the number of combine harvesters in the 1950s was said to herald its demise. But recent evidence is far more encouraging.

Left: A harvest mouse in a wheat field, probably its best known traditional habitat, although according to a recent survey only 5% of harvest mice live in cereal fields today.
In the last century harvest mice were a common sight in cereal fields. However, the advent of mechanical reaping machines meant that fewer mice were seen during the actual harvest, and other changes in agricultural practices generally made cereal fields a less desirable habitat. Weed killers and insecticides reduced the amount of food available and mechanical sowing machines ensured that the seeds were evenly spaced during planting, thus reducing the amount of cover available to the mice.

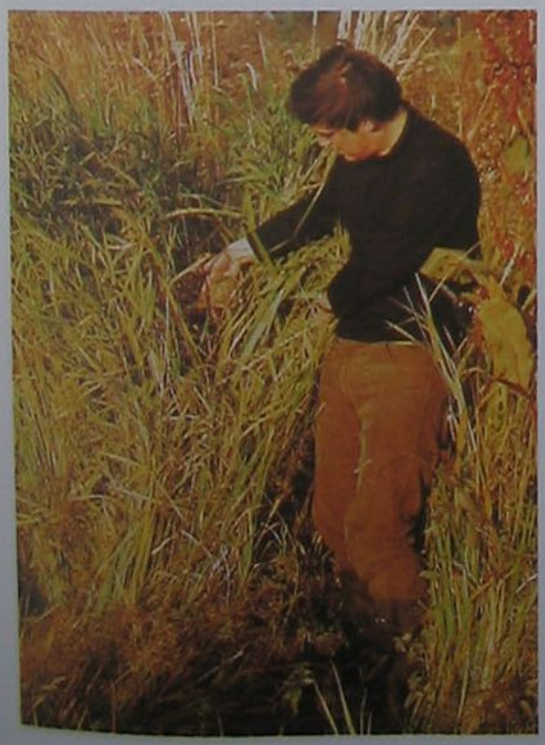
In the last century harvest mice were frequently seen living in cereal fields, where they built their nests among the forest of stems. At that time cereals were an ideal habitat for harvest mice. Many crops were hand sown, which resulted in the plants growing in clumps rather than being evenly spaced, and these clumps of stems gave the mice extra cover. Many of the fields were full of weeds and insects, both of which supplied ample food for the mice before the crops were ripe in late summer.

The crops were harvested by hand, and the cut cereals stood in stooks in the fields, giving the mice plenty of cover to protect them from the rooks and other predators following the harvest. The stooks were later stored in large cereal ricks, which were not threshed until much later in the winter. In the meantime, the mice were either carried to the ricks in the stooks, or migrated there themselves, where they probably continued to breed. So by the time threshing came round, usually after Christmas, large numbers of harvest mice were to be seen – they were a common sight.

Today's harvest mice The changes in agricultural practice, especially since the 1950s, made cereal fields less desirable as a habitat. Harvest mice do not begin breeding until mid-May and the majority of litters (75%) are born in August and September. Most cereals grown today are early ripening varieties that can be harvested in June or July, and so are not available as a breeding habitat when the harvest mice need them. In wet summers, however, when the harvest may not be completed until the autumn, numerous nests may be seen in cereal fields, reminiscent of the sights of the last century. Perhaps one of the biggest hazards facing any harvest mice that do venture into modern cereal fields is the practice of stubble burning the day following harvest.

No one really knew how the harvest mouse had fared, and so in the 1970s the Mammal Society organised a survey to find out. Since the mice themselves are so rarely seen, some easy technique was needed whereby large areas could be covered in the search without resorting to labour-intensive trapping sessions. Since harvest mice rarely enter traps, trapping is not a very useful survey technique anyway. However, harvest mice build nests which are very characteristic, easy to recognise and fairly easy to find. So the Mammal Society's survey was based on finding nests.

Nest building Harvest mice build two kinds of nests: large ones for breeding and small ones for shelter. The breeding nests are 5-10cm (2-4in) in diameter, or even larger, and are nearly always built above ground level among the stems of any species of grass. Each spring as soon as the grasses have grown tall enough the harvest mouse climbs among the stems to find a suitable site to build its nest. It then sits on a stem holding on with its



Left: A nest in reed-grass leaves, half way up the flowering stem and about 1.2m (4ft) above ground level. Nests are found in a similar position in other grasses which have leaves all the way up the stem – reeds, cereals and many hedgerow species, for example. The other type of grass, such as the familiar cock's-foot (right) and purple moor-grasses, have shorter flowering stems that lack leaves. In tussock-forming grasses the nests are usually built on top of the tussock at the base of the flowering stems, although they may also be built under the overhanging leaves on the sides of the tussock. In these cases the nest may be only a few centimetres off the ground.

Above: A typical harvest mouse nest built in reed-grass, showing how the leaves are shredded but left attached to the grass stems. The nest hangs freely between the stems rather than being built around them. Occasionally one or two stems may be accidentally engulfed by the nest, but they do not play any role in supporting the nest. Harvest mice nests are robust and in most years survive for much of the winter, despite rain, frost and snow.

Above: The two species that most frequently build nests in the same habitats as the harvest mouse are the reed warbler (top) and the dormouse (above). The reed warbler's nest is deep, cylindrical and cup-shaped, woven around the upright stems of plants, usually reeds. It is made from grass stems, flower-heads, leaves, down and even spiders' webs. The large breeding and shelter nest of the dormouse is domed, rather untidy and without any definite entrance. It is usually made of hedgerow plant species and the grass is not shredded.

hind feet and prehensile tail, so leaving its fore-feet free for building.

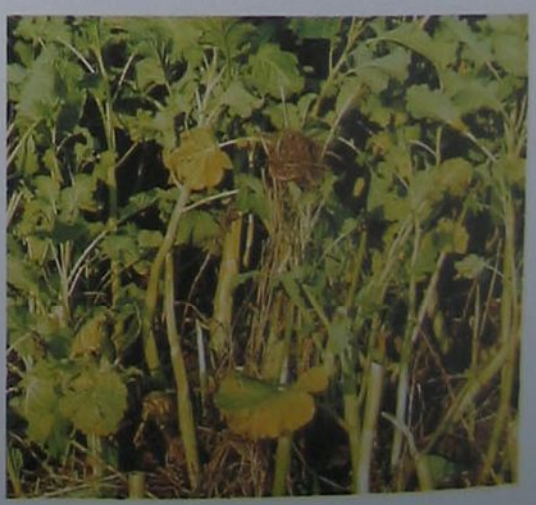
The mouse takes a nearby grass leaf and fastens its incisor teeth around the outermost rib. Working from the middle to the end, it splits the leaf by jerking its head backwards, while still holding it in its fore-feet. The leaf splits along its length; with long leaves the mouse may have to repeat the exercise two or three times to split off one strand. This is continued with the next vein, then the next, until the free end of the leaf has been shredded into a number of strips. These strips are all still attached to the bottom half of the grass leaf, which in turn is still attached to the grass stem.

A narrow leaf may be split into six or eight strips; a wide one, such as a reed leaf, may be torn into 20 strips or more. Staying in the same position, the harvest mouse repeats the process with 20 or more leaves, first shredding them and then weaving them into strips to form the framework of the nest. The leaves are usually living and green, and the nest is perfectly camouflaged. As the leaves are left attached to their stems, the nest hangs freely at the end of the shredded grass leaves. It is very rarely built around the grass stems, and then only one or two stems may be accidentally engulfed by the nest; they do not play any role in supporting the nest.

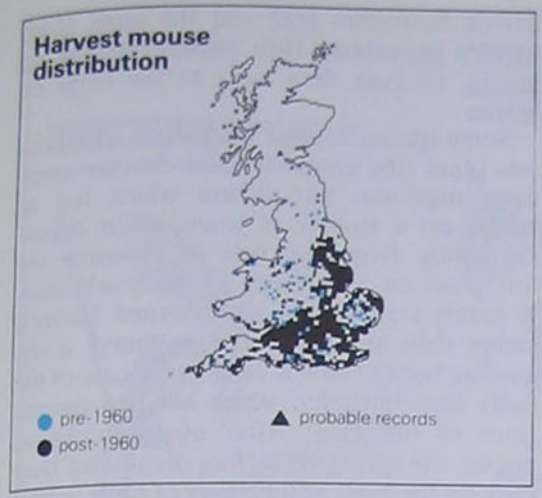
To complete the nest, the mouse continues to work from the inside. It pulls more leaves through the nest wall and either shreds them in a similar manner or finely chews them. The innermost part of the nest is packed solid with finely chewed grass or thistledown. Any central chamber develops later from use.

Obviously this method of nest building is totally dependent on the use of grass leaves. Broadleaved plants, with their branching and reticulate veins, will not split in the same way as grass leaves, with their long, parallel veins. This is why harvest mice are always found in grassy areas during the breeding season. From the harvest mouse's point of view, grasses are of two basic types. Some have tall, flowering stems with leaves all the way up the stem. These include reeds, reed-grass, cereals

Right: A harvest mouse nest in sedges—the mice have shredded the very long tough leaves. The nest is built over standing water.



Far right: A nest built in grasses among kale in a field. Sometimes the nests are in the heads of the kale or, as in this case, among the stems.



and many hedgerow species. The second type, such as the familiar cock's-foot and purple moor-grass, have shorter flowering stems that lack leaves.

Many smaller shelter nests are also built. They are usually 5cm (2in) or less in diameter, much more flimsy, often not lined, and usually built in similar situations as the breeding nests or in the base of grass tussocks, close to the ground. They provide cover for one mouse for not more than a few days and can be built in an hour or two. The breeding nests take at least a night to prepare and require some practice before the mice become competent nest builders.

While shelter nests are built all year round, breeding nests are only built from mid-May until late September, after which time the nests are slowly destroyed by winds and rain. In exceptional years, if the autumn is warm and dry, breeding may continue into late November or early December, but this is very rare. With the onset of inclement weather, the harvest mice spend much less time climbing in the grasses, and live in the base of grass tussocks, hedgerows and similar situations. If the mice have spent the summer nesting in wet, marshy areas they will migrate to a dry situation to overwinter.

Looking for nests The time to start looking for harvest mice nests is from late September onwards when the mice have finished breeding. It is then safe to start trampling the habitat and parting the grasses in a search for nests. If you are worried that a nest is in use, carefully insert a finger through the nest wall. If young mice are present, leave the nest and surrounding area well alone.

Harvest mouse nests are fairly robust and in most years will survive through most of the winter, and so there are at least three or four months in which to search for nests. No other nest can be confused with those of the harvest mouse, although the two species most frequently found nesting in the same habitats are the reed warbler and the dormouse.

Once it was established that nest hunting was a reliable survey technique, the Mammal Society used it to good effect. Far from confirming that the harvest mouse was rare or declining, the survey found that it was much more widespread than previously supposed. In fact, the mouse has literally gone unnoticed for decades and is common even in south and east England. From the North York Moors and Cheshire northwards it is very rare, but is still found as far north as Edinburgh. In Wales records are few, and it would seem that the mouse is widely distributed but rare in the coastal belt of Wales.

The survey also showed that harvest mice can be found in a wide variety of habitats. The most popular sites for nests were hedgerows (13% of records), followed by bramble patches (11%), field edges (10%), ditches and reedbeds (both 9%). In fact 1205 records were collected from 43 different habitats, including gardens, rubbish tips, potato and kale fields. Some were on the edges of motorways, and one nest was on a rubbish tip close to the centre of Exeter. Of the grasses used for nest building, cock's-foot was easily the most popular (21%), followed by reed-grass (14%) and reeds (10%). Nests were recorded from 38 species of grass.

Left: In the last few years we have learnt much about the harvest mouse; we now know that many of our old ideas about its being rare or declining are false. But there is still more to learn. For many areas of the British Isles we do not know how common harvest mice really are, and so we need more records from throughout the country. In particular we need to know if the mouse is really so rare in northern England, and if it is really only found in one part of Scotland, and so rare in Wales?

Below: A harvest mouse in a less common habitat – raspberry canes. The mice eat such fruits as raspberries, blackberries and rose-hips.

INSECT EGGS: THE FIRST STAGE

Most insects lay eggs, but the way in which this is done, the number of eggs laid by each species, and their shape and size vary considerably.

Above: The female lacewing fly touches a leaf with the tip of her abdomen and then raises it, drawing out a sticky thread which instantly hardens and forms a 'tail' with the egg attached to the free end. Clusters of these eggs can be found on the undersides of leaves in summer.

Below: Sawflies are equipped with sharp-toothed ovipositors, used by the females to cut slits in plants, into which they insert their eggs.

Egg laying in insects is particularly diversified, much more so than in birds, and can be said to vary in three main respects: the mode of laying the eggs, the number laid by the individual, and the size, shape and pattern of the eggs themselves.

Scattering and planting When the larval foodplant of a species is abundant, the female insects tend to scatter or drop their eggs at random. Examples include the marbled white butterfly, whose caterpillars feed on grasses, and the swift moths, whose offspring feed on bracken roots.

More usually, female insects place or implant their eggs in situations where the hatchlings can find appropriate food. Most female butterflies seek out the same plant species on which they themselves fed as larvae, sticking their eggs to the twigs or leaves.

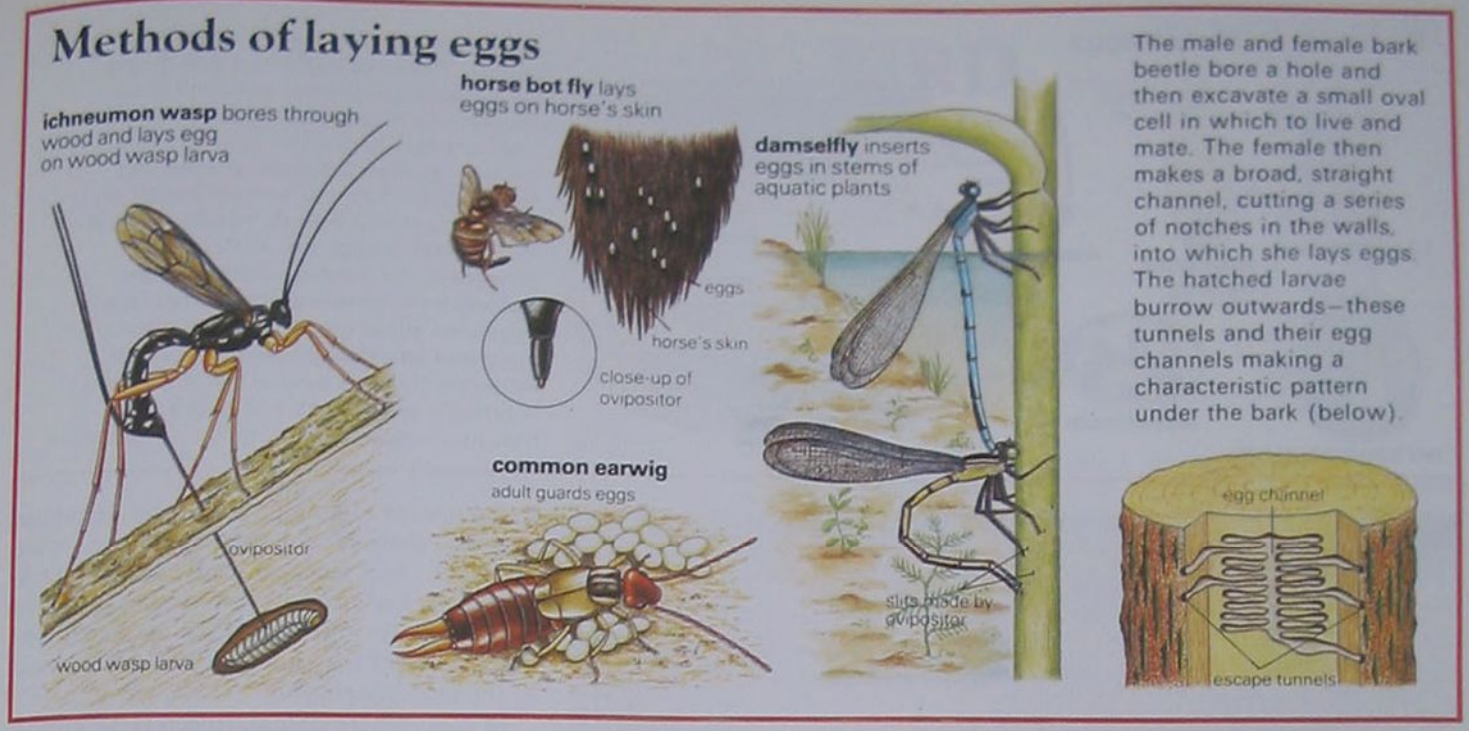
Some species confine themselves strictly to one plant (the cinnabar moth favours common ragwort), but others which fed as larvae on a variety of plants must depart frequently from the rule of choosing the foodplant on which they formerly subsisted. It seems certain that an inherited instinct, rather than any individual 'memory', is the guiding factor. This is clear in the case of the holly blue butterfly, which has two generations of offspring. After overwintering as pupae, the spring butterflies usually lay their eggs on the buds and flowers of holly, where the larvae then feed. However, the butterflies of the second generation, which fly in late summer, lay their eggs on buds of ivy, where again the larvae feed.

Eggs in slits Leaf beetles also stick their eggs on to the leaves and stems of particular plants, but weevils – also specific plant feeders – bore holes in seeds or fruits with the tiny mandibles at the tips of their long snouts. They then turn around, insert their ovipositors in the hole and lay an egg. Crops of peas, beans and hazel nuts may be seriously damaged by weevils in this way.

Another notable group of insects which implant their eggs are the sawflies, so named because the females are equipped with sharply toothed ovipositors which they use to cut slits in plants, into which they insert their eggs.

Parasitic insect eggs Insects whose larvae are parasites usually lay their eggs on the host's skin or implant them by means of a piercing ovipositor. The large ichneumon wasp *Rhyssa persuasoria*, having located a wasp larva deep in a tree trunk, bores through the wood, and then passes down an egg which it implants on the victim's skin.

Lice stick their eggs firmly to the hairs or feathers of mammals and birds which they infest, while warble flies lay theirs on the legs of cattle so the larvae can penetrate the animal's skin to commence their annual cycle of development in successive parts of its


Methods of laying eggs
ichneumon wasp bores through wood and lays egg on wood wasp larva
ovipositor
wood wasp larva
horse bot fly lays eggs on horse's skin
eggs
horse's skin
close-up of ovipositor
common earwig
adult guards eggs
damselfly inserts eggs in stems of aquatic plants
slits made by ovipositor
The male and female bark beetle bore a hole and then excavate a small oval cell in which to live and mate. The female then makes a broad, straight channel, cutting a series of notches in the walls, into which she lays eggs. The hatched larvae burrow outwards – these tunnels and their egg channels making a characteristic pattern under the bark (below).
egg channel
escape tunnels

body, finishing just under the skin of the host's back.

Aquatic eggs Insects which pass the early part of their life in the water usually have particularly interesting egg-laying habits. The damselflies and some dragonflies (the common hawker dragonfly, for instance) insert their eggs in the stems of water plants, in much the same way as the sawflies do on land, while other species of dragonfly (such as the broad-bodied libellula) fly over the water, either dropping their eggs, or splashing the tip of their abdomen into the water to wash off the eggs. The larvae are hunters and require only to be introduced into water where their prey is found.

Guarding the nest Nearly all insects, other than social insects, lay their eggs with provision for the larvae when they hatch, and then leave them.

A few species, however, including the common earwig and the parent bug, guard and brood their eggs until they hatch. Earwig nests may be found under bark and stones in early spring, while you are most likely to see a parent bug guarding its eggs on a birch leaf.

Safety in numbers In general the quantities of eggs laid depend on the hazards that the larvae are likely to encounter. (Social insects whose females lay large numbers of eggs are a special case.) Between 100 and 300 eggs are usual, but the garden chafer beetle, for example, lays an average of only 14 eggs – in such instances it is hard to see how the survival rate of the larvae can be sufficiently high to maintain the species' existence.

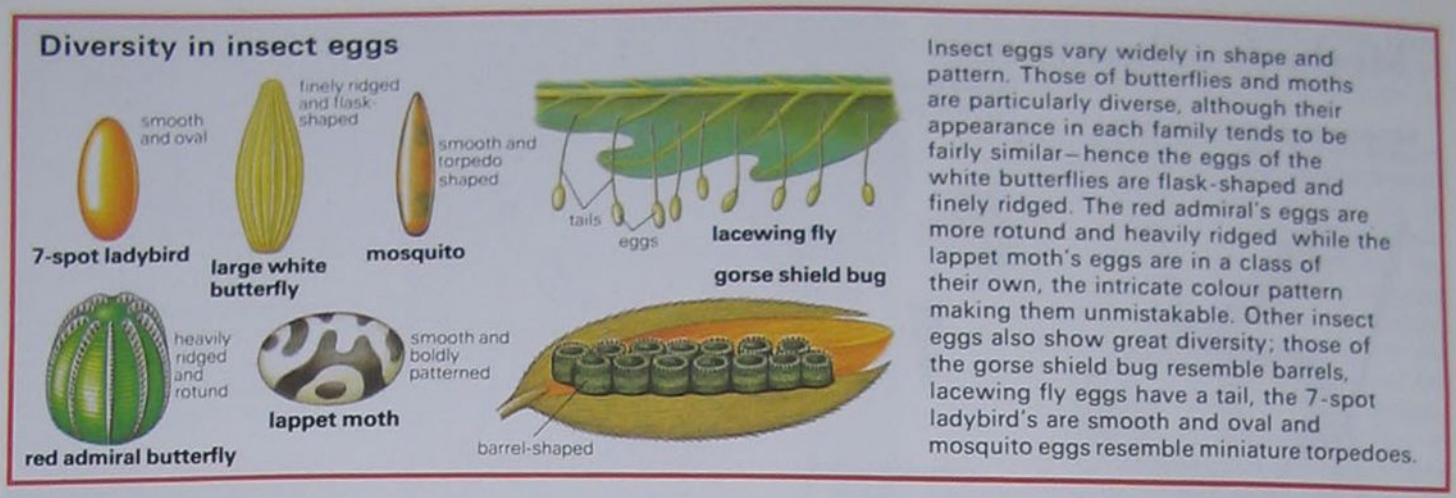
At the other extreme, the female oil beetle lays several thousand eggs in batches on the ground – a safeguard which is more than necessary since the number of individuals that survive the hazardous larval stage is small. The tiny oil beetle larvae climb on vegetation and seize on to any hairy, winged insect that comes near; it could be any species of fly or bee. Only those larvae which attach themselves to a particular solitary bee (*Anthophora* species) survive. They are carried to the bee's nest, where they live as parasites. The rest – a very large majority – perish without developing any further.

Solitary bee cells Bees, wasps and ants comprise the more advanced members of the order Hymenoptera, and it is among these insects that care for the eggs and welfare of the larvae reach their highest levels.

The majority of bees and wasps are solitary – they do not live in the large colonies characteristic of the more familiar social

Above left: The many ways in which insects lay eggs.

Below: Insects which pass their early stages in the water tend to have specialised egg-laying habits. The plume midge, for instance, provides its eggs with a minute float which keeps them on the water surface, and sticks them together to form a raft. Mosquitoes also lay their eggs in this way, although the eggs may be laid singly, or they may be stuck together.


Diversity in insect eggs
smooth and oval
7-spot ladybird
finely ridged and flask-shaped
large white butterfly
smooth and torpedo shaped
mosquito
tails
eggs
lacewing fly
gorse shield bug
heavily ridged and rotund
red admiral butterfly
smooth and boldly patterned
lappet moth
barrel-shaped
Insect eggs vary widely in shape and pattern. Those of butterflies and moths are particularly diverse, although their appearance in each family tends to be fairly similar – hence the eggs of the white butterflies are flask-shaped and finely ridged. The red admiral's eggs are more rotund and heavily ridged while the lappet moth's eggs are in a class of their own, the intricate colour pattern making them unmistakable. Other insect eggs also show great diversity; those of the gorse shield bug resemble barrels, lacewing fly eggs have a tail, the 7-spot ladybird's are smooth and oval and mosquito eggs resemble miniature torpedoes.

Above: The eggs of the gorse shield bug are shaped like tiny barrels with lids that the young push open when they hatch.

members of the order (honey bees, for instance). A female solitary bee, after mating, finds or constructs a hollow space for her nest. Some species burrow in the ground, while others use ready-made holes.

One solitary bee species, *Osmia rufa*, gladly accepts a piece of bamboo, placed horizontally in the open, as a nesting site. First the female closes the end of the bamboo with clay, and then she collects pollen and nectar, placing a store of honey-and-pollen paste against the clay. On this she lays a single egg and then makes a clay partition, leaving a closed cell two thirds full of rich food – just sufficient for the larva until it is fully grown. She then repeats the process until the bamboo tube is full of cells.

In each cell a larva hatches, feeds, pupates and eventually emerges as a bee which bites its way through the clay partitions to the exterior. Solitary wasps have a similar pattern of breeding behaviour, but they stock their cells with paralysed insects or spiders as food for the larvae.

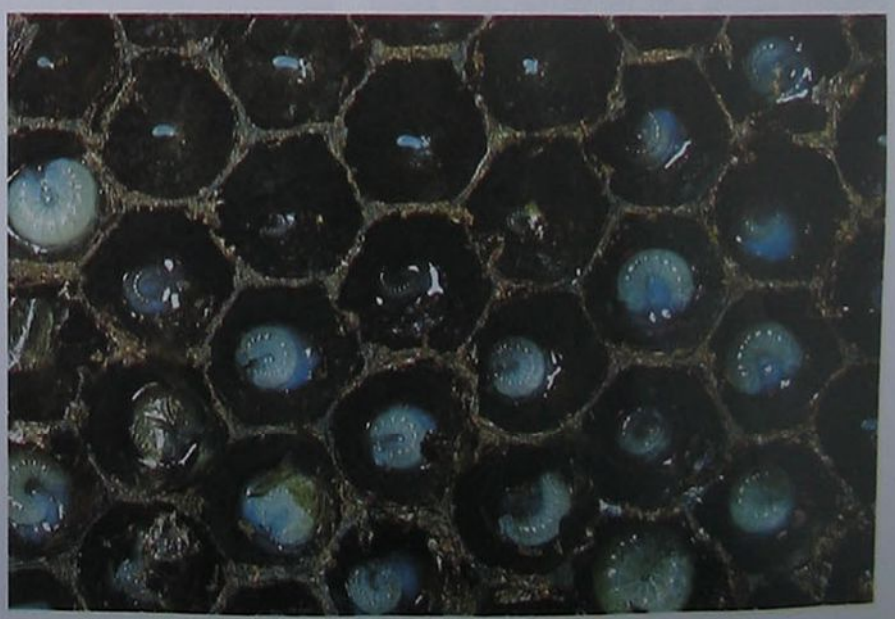
Honeycombs The breeding habits of the social Hymenoptera have evolved from those of the solitary species. In Britain these comprise a few species of bees and wasps, and all ants – there are no solitary ants. These social insects exist in large colonies inhabited by vast numbers of sterile females called 'workers' and one, or only a few, fertile females called 'queens'. Males are produced in the colonies at certain times of the year and die soon after they have fertilised the queens of the next generation.

In cases where a single queen is the mother of the entire population she must lay vast quantities of eggs – a single queen honey bee may lay well over 100,000 eggs during her life of two to five years.

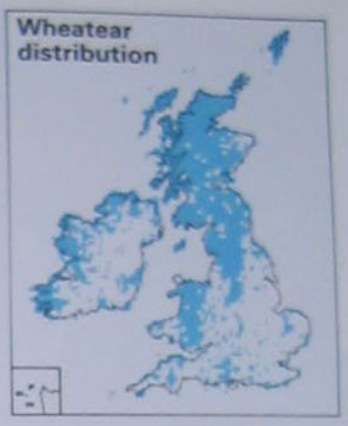
Social bees and wasps construct large nests furnished with closely packed cells in which the queen lays her eggs, one in each cell. Bees and wasps make very similar, beautifully regular, hexagonal cells, those of the bees being made of wax, and the wasps' of a papery substance made from chewed wood. When the larvae hatch the workers feed them from their mouths.

Untidy ant nests Ants have complicated habits but they are poor architects, never making regular cells to contain the eggs. When the eggs are laid by the queen, the workers simply gather up the eggs in clumps and carry them to parts of the nest where the temperature and humidity are favourable for their development.

Below: A honeycomb showing the bee larvae in the cells.



THE WHEATEAR: BIRD OF THE OPEN SPACES



Despite its name, the wheatear does not eat ears of wheat, nor does it usually live near cereal fields; in fact it eats insects and lives in open, grassy places. However, its name does have some meaning, since it derives from the Anglo-Saxon for 'white rump', which is the bird's most conspicuous feature.

The wheatear is a little larger than the robin, and not dissimilar in shape and feeding behaviour. Like the robin, it feeds from the ground, hopping some distance and then standing bolt upright to survey the grass, often flicking its wings and tail in a distinctly alert and ready-to-pounce fashion. It makes full use of raised points such as hummocks or boulders, since these give a wide field of view. Adult and larval insects form the main prey, but other invertebrates such as snails, millipedes, spiders and worms are also taken. Some insects are even caught in mid-air if they fly close enough.

The plumage of the male wheatear is full of sharp contrasts: black wings and eye 'mask' stand out from pale grey upperparts and whitish underparts, and black tips to the tail feathers highlight their white bases and the white rump. This white rump is the most conspicuous feature of wheatears of both sexes. On most males, the throat and breast are pale buff, fading gradually to pure white on the undertail coverts, and there is also a white stripe above the eye 'mask'.

The female's plumage is less contrasting: black is replaced by dark brown, and grey by paler brown. Thus, for example, her facial markings are not at all conspicuous. Beneath, she is buff coloured, with little trace of white. Nevertheless, she does have the white rump, so that identification is normally easy.

Open habitats Several other species of birds have white rumps, including the bullfinch, jay, brambling, house martin and several waders, but these all live in quite

Above: Wheatears are commonest on sheep-grazed uplands, coastal headlands, shingle banks and islands.

Below: The chicks hatch 14 days after the last egg is incubated. After only 15 days in the nest they are able to fly, and not long after that they are fully independent. These three juveniles have just fledged; at this stage, they are particularly attractive, being heavily speckled. The growth of these young birds is so rapid that both parents have to collect food for them.

different habitats–at least during the summer when wheatears are here–and have very different patterns of behaviour. A small bird with a conspicuous white rump, feeding on open ground, is almost certainly a wheatear. The species is also characterised by constant activity–flitting from one place to another–so the birdwatcher rarely has to wait long for one to alight nearby, giving a good view.

In spring and autumn, when they are on their way to or from their breeding grounds, wheatears are seen in most open habitats–beaches, grassland, ploughed fields, waste land, coastal headlands and rough tracks–but such birds are merely passing through, and usually move on after a day or so when they have found sufficient food to last through their next flight.

Above: On the breeding grounds, wheatears (this is a female) blend marvellously into the background, their grey, white and black plumage looking just like lichen-covered rocks. But listen for their alarm calls as you approach. 'Chack-chack' is the usual call, or 'weet-chack-chack'.

Below: The male wheatear is instantly distinguished from the female by his black eye-stripe and bold colours.

In the breeding season they are more particular. At this time, short turf seems to be the major requirement, since it supports the insect population on which they feed. Sheep-grazed upland is ideal and many wheatears live on the hills and mountains in the north and west, even at altitudes of over 1000m (3300ft). Windswept coastal headlands, shingle banks and even small islands provide suitable habitats in which wheatears thrive.

However, in southern and eastern England, wheatears have become quite rare. Until the turn of the century, chalk downland and heathland used to hold quite large populations. Roast wheatear was commonly eaten as a delicacy, and shepherds used to sell wheatears which they caught on the downs, without any significant impact on the breeding numbers.

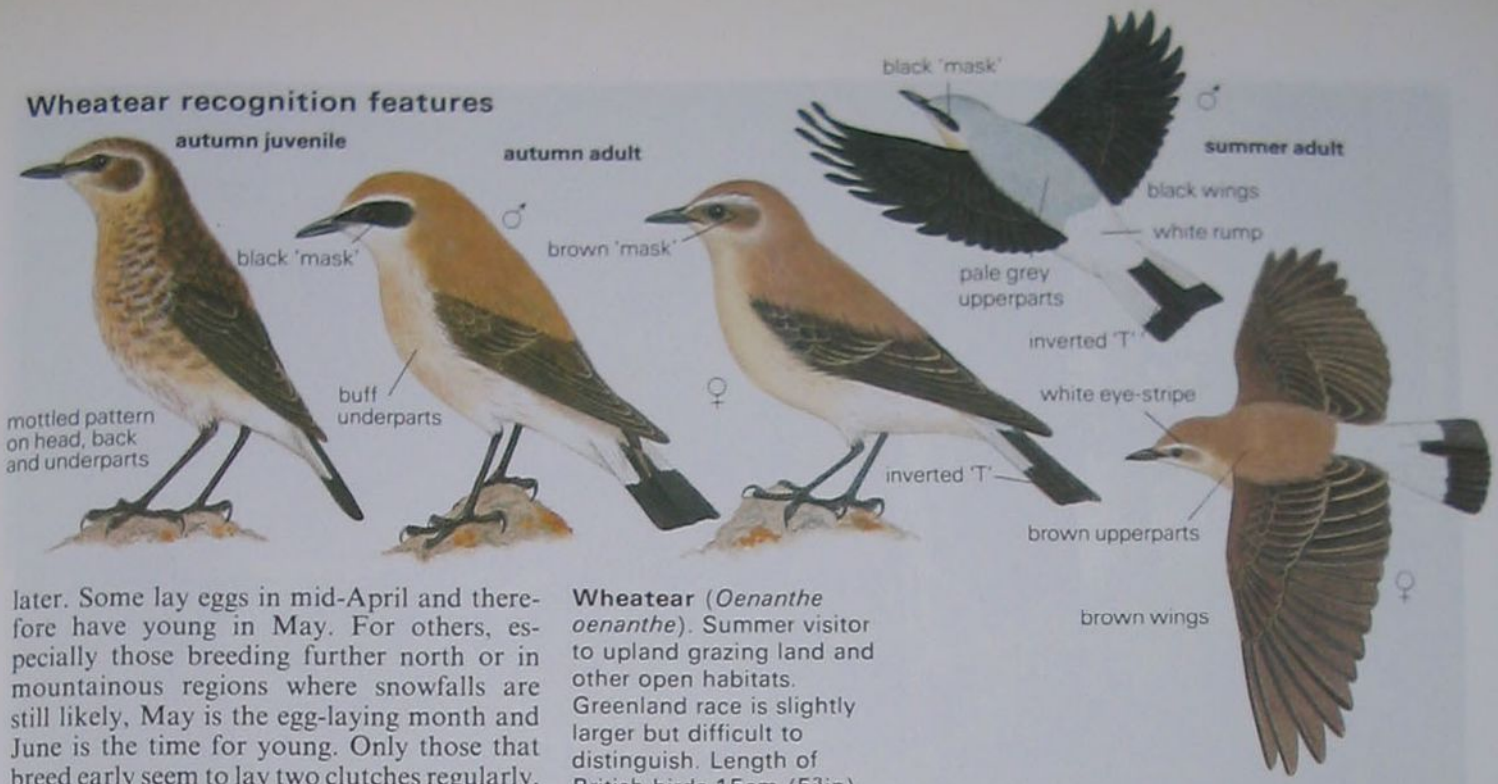
It was the decline in sheep farming which seriously affected the wheatear population, since the grass then grew long and scrub invaded, rendering the land quite unsuitable. A reduction in the number of rabbits as a result of myxomatosis made things worse, and today relatively few of the traditional wheatear breeding sites are occupied.

Assortment of tunnels Wheatears also show a strong preference for areas with dry stone walls, scree slopes or abandoned buildings. This is because, unlike many birds of open grassland areas, wheatears require more than a simple tussock in which to place their nest. The ideal nest site would be a sheltered hollow at the end of a rocky 'tunnel'–perhaps several feet long–easily reached by the birds but totally inaccessible to predators such as the fox. Where rocks are not available, interesting alternatives have been recorded. For example, at Dungeness in Kent, where wheatears breed on shingle, nest boxes, drain pipes and even discarded ammunition boxes have proved adequate. On downland, old rabbit burrows provide ready-made tunnels for some wheatears.

Breeding wheatears The male defends the territory by means of song and display. Although delivered with great enthusiasm, the song is not particularly tuneful. It does contain some melodious warbling notes, but these are mixed with harsh scratchy sounds in a short, rather jumbled sequence.

Meanwhile, the female builds the nest, collecting dry grass stems first for the main structure and then feathers, wool or hair for a smooth warm lining. In neither nest-building nor incubation does the male give her much help. Later, when the chicks have hatched, he comes to her assistance, for the young develop rapidly and the work of both parents is needed to sustain their growth.

Migration schedule On the south coast of England, the first wheatears usually arrive from their African wintering grounds in early March. Most of them arrive about a month



later. Some lay eggs in mid-April and therefore have young in May. For others, especially those breeding further north or in mountainous regions where snowfalls are still likely, May is the egg-laying month and June is the time for young. Only those that breed early seem to lay two clutches regularly, the second brood fledging in July.

August and September are the main departure months, though some wait until October. Before they leave, all the adult birds moult into their winter plumage, growing a whole new set of feathers in just a few weeks. The young birds, too, grow new head and body feathers. Males, females and young birds look very similar at this time: all resemble females in summer plumage.

Marathon migrants Wheatears breed throughout most of Europe and northern Asia, but also in the extreme north-western and north-eastern parts of North America. This distribution, and the fact that all wheatears migrate to tropical Africa for the winter, suggests that the species originated in the Old World and only spread to America in recent years. For example, no wheatears winter in South America.

As a result, some wheatears fly phenomenal distances during their migration. Those from Greenland have to make a 3200km (2000 mile) sea crossing over the North Atlantic to Ireland, Britain or Spain – a remarkable non-stop flight for so small a bird. Needless to say, such birds must build up large reserves of energy-rich fat in their bodies before setting off; there is no chance of refuelling on the way, and certain death results if the supply runs short. Those that reach dry land arrive tired and hungry, and only two-thirds of their starting weight.

The Greenland wheatears These are slightly larger than British wheatears, and they tend to stand more upright. They perch in tall trees much more frequently than ours do, and, at least in spring, they have more richly coloured underparts. Finally, the Greenland birds tend to pass through this country rather later than our own, both in spring and summer. Their peak passage months are late April/early May, and September/October.

Wheatear (*Oenanthe oenanthe*). Summer visitor to upland grazing land and other open habitats. Greenland race is slightly larger but difficult to distinguish. Length of British birds 15cm ($5\frac{3}{4}$in).

Right: Seven unmarked, pale blue eggs are the usual clutch, but both the colour and the number vary. Thus, some eggs have dark spots, and some females lay up to eight or nine eggs – especially those in the far north of the breeding range.

Below: A pair of wheatears at the entrance to a tunnel – probably an old rabbit burrow that the birds have taken over. The female (holding a grub) has more buff-coloured underparts and the male's are whiter.

SAVERNAKE: AN OAK AND BEECH FOREST

To speak of Wiltshire is to conjure up images of rolling downs and skylarks soaring through the sky. For the most part this picture is true, yet there are also more shaded, woodland places. One such is Savernake Forest, an ancient royal hunting ground.

Lying just south of Marlborough, Savernake Forest once provided a convenient and diverting stop-over for hungry kings and princes en route between London and the West Country. Indeed, the attractive market town of Marlborough continued to provide the same break in journeys until the M4 motorway arrived to change the habits of

Above: Some of Savernake's splendid beeches in early spring foliage.

Right: Wood sage is one plant that flourishes in the sunlight-dappled glades.

centuries. In the middle ages an unbroken tract of forest extended from the town of Marlborough to the Solent in Hampshire. Today, Savernake occupies some 930ha (2300 acres), of which 375ha (930 acres) have been designated as a *Site of Special Scientific Interest*.

Above: The nuthatch is one bird to look for among the trees of Savernake. The slate-blue upperparts and orange-buff underparts make it easy to identify.

Below: Oak and beech trees predominate in Savernake, and in spring the woodland floor can be a mass of seedlings. In beech seedlings the cotyledon or seed leaves are raised off the ground by a stem, while in the oak they never emerge from the acorn.

The Forest The underlying geology, like that of the nearby Marlborough Downs, is chalk but is here overlaid for the most part by superficial deposits of clay-with-flints and, in some places, sand. Ancient forests typically encompass a wider range of habitats than just woodland, and Savernake is no exception. Open areas occur in shallow valleys which bisect the Forest. In the west they are calcareous but in the east deposits of sand give rise to heaths.

The woodland itself is predominantly oak and beech, but with quantities of birch and hawthorn as well. Magnificent beech-lined avenues, laid out by 'Capability' Brown in the 18th century, radiate out like the spokes of a wheel from the centre of the Forest. On the map they appear to be a monstrous human imposition upon the ancient oak woodland, but at ground level the lofty beeches, themselves now two centuries old, merely keep prying eyes away from the many hidden glades out of which roe and fallow deer slip at dusk or in the early morning light to feed.

The most stately of these 18th century accomplishments is the Grand Avenue, which runs for some four miles in a north-west/south-east direction across the Forest. Planted with elm and beech, an impressive vista is provided from Tottenham Park, the former home of the Marquesses of Aylesbury, to the tall column which was erected to celebrate the return to sanity of George III. The woodland is divided into segments by eight paths, laid out from the centre along the cardinal points of the compass, and down which visitors can walk or ride.

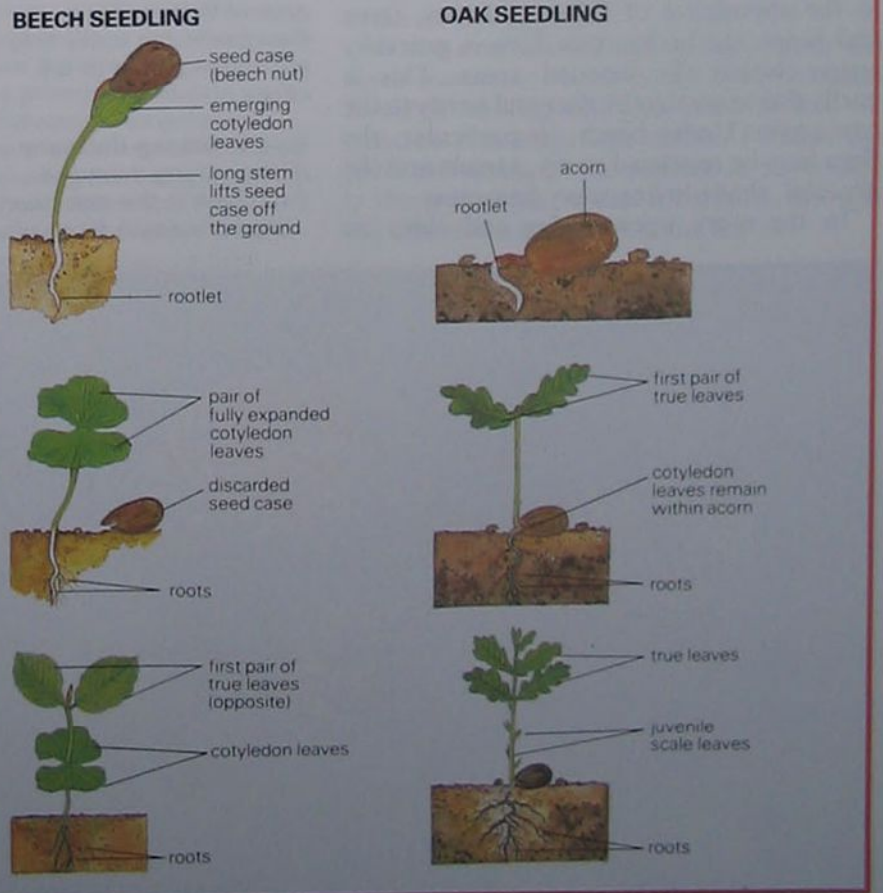
Traditionally, the management of the Forest lay with the Warden, an hereditary post whose present incumbent, the Marquess of Aylesbury, relinquished his powers to the Forestry Commission in 1939.

Although a certain amount of afforestation with conifers has taken place, the Forestry Commission has generally respected the essential broad-leaved character of Savernake and recent plantings have included oak. Two species of oak occur – the common or pedunculate oak and some very ancient and massive stands of sessile oak, of which the 'King' and 'Queen' oaks are the best known specimens in the Forest. (The pedunculate oak differs from the sessile in possessing stalks on its acorns, but hybrids also occur.) An extremely rich lichen flora of over 100 species is associated with the sessile oaks, whose epiphytic flora also includes mosses and polypody ferns. Silver birch thrives in the sandier areas of the Forest, where it tends to encroach upon the remaining open areas of heath.

Flourishing fungi Among the birches in late summer you may find the poisonous fly agaric fungus. With its handsome, white-spotted red cap this picture-book toadstool is instantly recognisable, yet far more deadly is its less familiar close relative, the death cap, whose streaked greenish-yellow cap is to be found beneath beech and oak.

The realistic-looking beefsteak fungus, on the other hand, while not exactly a chef's delight, is at least edible. The flesh-coloured lobes of this bracket fungus not only have the colour, weight and fibrous texture of raw beefsteak, they even exude a red juice for

Seedling stages



good measure. This species is found on the stumps or around the bases of older oaks.

Savernake Forest is, indeed, renowned for the variety and abundance of its fungi, but unless identification is certain, they are best left untouched. Apart from the interest they provide, fungi perform a vital function in assisting the decomposition of organic material to provide humus, without which the life of the Forest would cease.

Savernake flowers and insects In contrast to the abundance of lichens, mosses, ferns and fungi, the herbaceous flora is generally sparse within the wooded areas. This is partly due to grazing by deer and partly to the tree cover. Under beech, in particular, the flora may be restricted to ivy, sanicle and the graceful, shade-loving wavy hair grass.

In the more open glades and rides an exuberant growth of bracken and foxglove predominates, along with purple moor grass, wood sage and several species of bramble. Herbaceous species are most abundant in the open areas, where they range from such typical calcicoles (lime lovers) as kidney vetch and wild strawberry on the exposed chalk in the west, to such familiar calcifuges (lime haters) as ling and gorse on the sandy heathland to the east. In recent years, however, these open patches have diminished in extent as trees and shrubs have come in to colonize. Birch, in particular, can rapidly take over what was once a heath of yellow gorse and purple heather.

Above: The fallow deer is one of four deer species inhabiting the Forest. (The other three are the red deer, roe deer and Chinese muntjac or barking deer.) Some of Savernake's 100-150 fallow deer live in the deer park, but the remainder run wild. Deer have been hunted in the Forest from at least the days of William the Conqueror, but today they are no longer put to the chase.

Below: Among the many different fungi found in Savernake is the attractive – but poisonous – fly agaric.

Gorse is represented in Savernake by two species – the common gorse or furze, which flowers throughout the year but is at its best from April to June, and the smaller, more prostrate dwarf gorse, which does not flower until July. Smaller still is another yellow-flowered relative, the petty whin, a spiny, almost hairless undershrub with wiry stems and small pointed oval leaves.

As its ponds have silted up and become overgrown, the wet places of the Forest have also tended to decline. Where they persist a refuge is provided – not only for such specialised plants as blinks, water purslane and shoreweed, but also for the amphibian population of frogs, toads and newts.

Like the flowering plants, most butterflies favour the rides and glades or the more open areas of heath and down. Wild violets provide the foodplant for several species of fritillary butterfly, while the kidney vetch caters for the small blue and gorse supports the green hairstreak. Other butterflies, such as the speckled wood, marbled white, meadow brown and ringlet, are content with coarse grasses. Like many of Savernake's

rarer butterflies, the purple hairstreak is dependent upon the oak for its survival and rarely descends to ground level. Rare beetles and flies also rely on the mature oaks, single trees having yielded over 600 different species of invertebrates.

Bird life Just as the plant life of the Forest provides for the insects, so the insects in their turn become food for the many woodland birds. As you might expect, all three species of woodpecker are present–these being the handsome great spotted woodpecker, its smaller relative the lesser spotted woodpecker, and the green woodpecker, whose laughing call betrays its presence as surely as does the harsh chatter of the jay. Sharper eyes are needed to spot the small brown treecreeper as it deftly climbs a tree trunk in search of insect larvae.

Summer migrants include the redstart. A shy bird, similar to the robin in size, the male redstart is dark grey above but with a bright chestnut-red rump, tail, breast and flanks. The woodcock, on the other hand, is a true Savernake resident, secretive by day and feeding mainly by night. Large, brown and well-camouflaged, the males are occasionally encountered at dawn or dusk when they circle their territory issuing a strange 'wizzick' call.

Hideaway deer Dawn and dusk are also the best times to see the equally secretive deer, of which four species are represented in Savernake. The largest of these is the native red deer, whose population of about 20 survives in the deer park just to the south of Tottenham Park. Only the stags bear antlers, using them to fight for females in the autumn rut, prior to which they can be heard roaring furiously, usually on the first clear frosty nights of late September.

The fallow deer, a long-established introduction to Britain (presumably by the Romans), is a native of southern Europe. Somewhat smaller than the red deer, its summer coat is a splendid reddish fawn ('fallow'), dappled with white spots which are lost in October when it acquires its drab winter coat.

Our other native species, the roe deer, predominates in the woodland; here individuals lie up during the day. A small graceful species, the largest bucks stand no more than 60cm (2ft) at the shoulder.

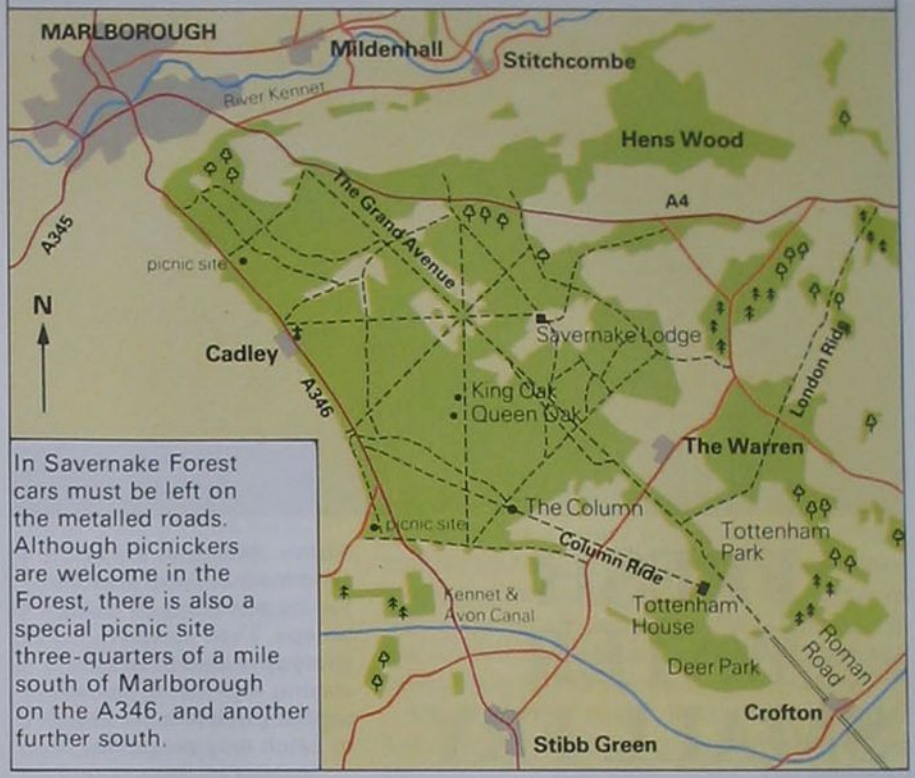
Left: A widespread plant of damp grassy places is the lady's smock or cuckoo flower, whose lilac flowers grace many a woodland path from April to June; it is the principal foodplant of several of Savernake's many woodland butterflies, including the orange-tip (shown here) and the green-veined white. Only the male orange-tip has the brilliant orange wing colouring; the female can be mistaken for one of the cabbage white butterflies.

Right: Savernake's rides and glades are favoured by the lovely but poisonous meadow saffron, whose pale mauve flowers have a crocus-like appearance which belies its membership of the lily family. The vigorous tufts of its large bluebell-like leaves precede the flowers, which do not appear until August or September–a feature which has given this plant its other common name of autumn crocus.

Savernake Forest

wooded areas
deciduous woodland
coniferous woodland
paths and rides

If you approach Savernake Forest on the M4 motorway, leave it at Junction 15 and travel the eight miles south to where the Forest lies like a green wedge between the A4 and the A346 (to Andover).



In Savernake Forest cars must be left on the metalled roads. Although picnickers are welcome in the Forest, there is also a special picnic site three-quarters of a mile south of Marlborough on the A346, and another further south.

The Chinese muntjac is a more recent introduction. Smaller even than the roe, it is identifiable by its white underside and short tusks in the upper jaw.

If the deer are shy of daylight, then the small mammals of the Forest are true night-dwellers, coming out after dark to feed on nuts, berries, slugs and insects. Perhaps the most endearing of the rodents in Savernake is the dormouse, which hibernates through the winter in a nest of moss and leaves.

FRESH WATER SMALL FRY

The tiny fishes of streams, rivers and lakes play important roles in the interlocking web of freshwater life, each in its characteristic habitat.

Above: Minnows are fast swimmers and are able to live by a strategy of quick escape. Their survival strategy is also based on staying together in schools so that predators are likely to catch only stragglers.

Opposite page top: The gudgeon, along with the bleak and bullhead, is at the top of the range of sizes in Britain's mini-species at 10-15cm (4-6in) in length. The smallest – the 9-spined stickleback – is only 3-4cm (1¼-1½in).

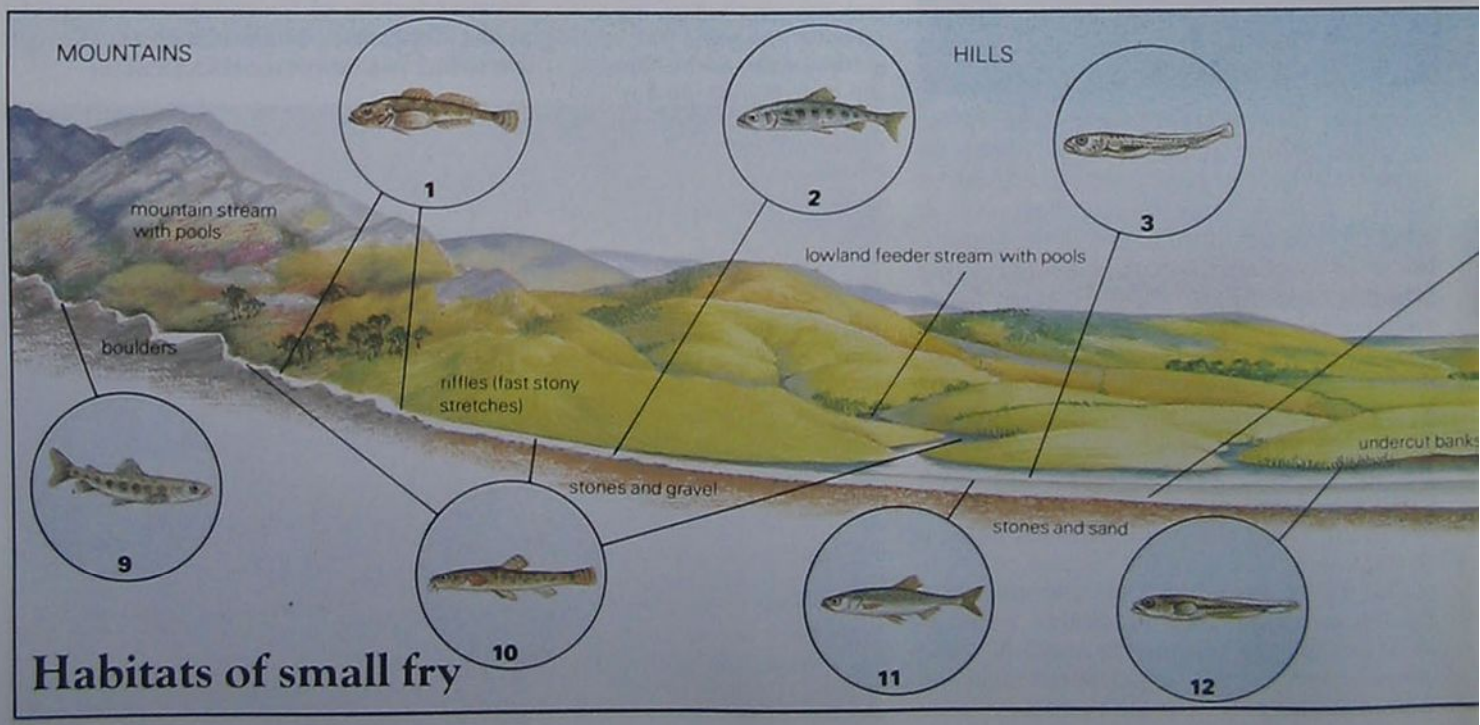
The word 'fry' can refer to the young fish newly hatched from the egg, or in its first weeks of life. It can also be used as a term for small fishes irrespective of their age – those that might be called the mini-species. So small fry can refer both to the young of the pike, which may grow into a fish of 25kg (55lb) weight, and equally to the fully grown 4cm (1½in) nine-spined stickleback, which is Britain's smallest freshwater fish.

Different communities of small fry occur in different habitats, for it is probably true to say that no two species or age groups have exactly the same requirements in terms of living space, food or spawning places.

Headwater streams Possibly the best known habitat for small fry is the small feeder stream at the headwaters of a river. In lowland areas these lie close to the hills in which the river rises, and may be no more than a metre or two across and 10-30cm (4-12in) deep, with occasional deeper pools at meanders in the stream. In such a situation minnows may be quite common. These live in schools, sometimes numbering hundreds of fishes, in the shallow, sun-warmed water. But they are wary fishes: the sudden appearance of an onlooker on the river bank sends them streaming in a long snake-like school upstream.

Where the water slows at pools, weed beds form, and in the mat of vegetation and plant roots, solitary species such as the stone loach burrow. Here the loach passes the day concealed from light; it is active only in the half-light of dusk and dawn. Loaches can also be found under pebbles in the shallow riffles (riffles are stretches where the water runs swiftly over a pebbly bed).

In eastern England, the locally distributed spined loach may be found in slow streams, but always buried in the river bed or in the



Habitats of small fry

mats of filamentous algae that grow in still areas on the river bed in summer.

Stony riffles–and also dense beds of watercress and other plants–are inhabited by the bullhead, a broad-headed little fish, growing to a length of 10cm (4in), with sharp curved spines on its gill covers. This fish is active mostly at night, and when at rest it lies concealed beneath the larger pebbles. Bullheads even spawn under the pebbles; the eggs are fixed to the roof of their private caves, and the male fish guards them.

Although all these fish are small and of little interest to the angler, it would be a mistake to overlook their importance, or that of the feeder streams. These are, for example, the nursery waters of the dace, which spawn in early March at the tail of the riffles, leaving their eggs among the pebbles to hatch out in about four weeks. Dace fry form small schools in the shallows at first, but soon join together to form larger groups. Without the modest headwater streams, many large rivers would be short of these beautiful, silvery fish.

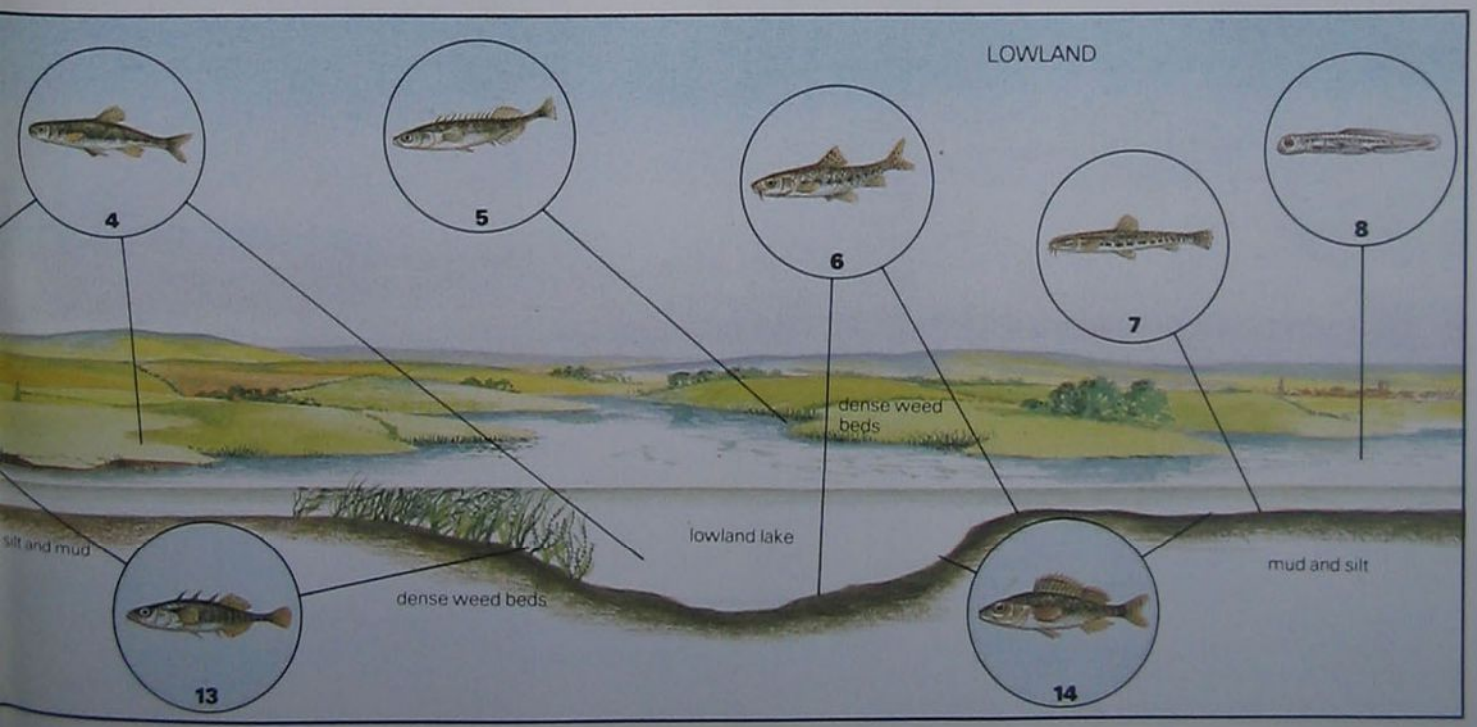
Trout streams In mountainous areas, streams tend to be more stony and the current fast: not surprisingly, different fishes are found here. Typical of this terrain are little becks not a metre across; in dry weather these contain only a trickle of water running into pools the size of a hand-basin. Like the lowland brooks, these becks contain bullheads and stone loaches, but they are of prime importance as the habitat of trout fry.

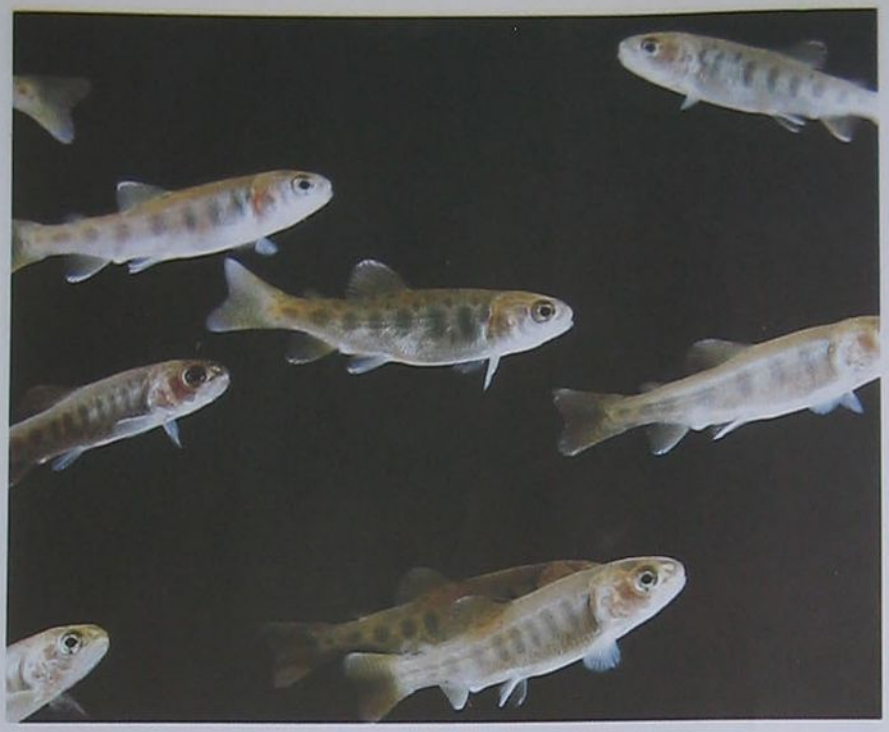
Young trout are often segregated by size, the larger ones living in the bigger pools and the smaller ones in tiny pools; but the biggest of them may be no more than 10cm (4in) long, and the individual pool occupied by one of these may be only the size of a kitchen sink.

Below: **1** Miller's thumb–a bottom dwelling species. **2** Salmon parr–lives among gravel on the bottom. **3** Young roach–dwells close to shore in the shallows. **4** Minnows–bottom or mid-water dwellers. **5** The 9-spined stickleback–lives among weed beds. **6** Gudgeon–a bottom dwelling species. **7** Spined loach–a bottom dwelling fish. **8** Bream fry–dwells near the shore region. **9** Brown trout–lives among boulders in pools. **10** Stone loach–a bottom dwelling species. **11** Bleak–dwells near the water surface. **12** Young pike–lives near undercut banks. **13** The 3-spined stickleback–still water with cover. **14** Ruffe–a bottom dwelling species.

As they outgrow their tiny habitats, the trout move downstream to the larger river or lake which the beck feeds. The 'nursery' habitat of their first year is well supplied with insects and other animals, most of which fall in from the banks or are blown in by the wind from neighbouring bushes and trees, but this supply would be totally inadequate for a larger fish. Living in the beck provides a relative immunity from predators, for larger fish-eating fishes and the carnivorous water beetle and dragonfly larvae do not live in such habitats, and even kingfishers and herons can find richer pickings elsewhere.

Small fry in rivers Rivers also provide habitats for species which are more often thought of as still-water fishes. The undercut banks of rivers often have a mat of grass and plant roots, willow stems and brambles hanging in the water. This provides a quiet area out of the current in which the three-spined stickleback thrives. Not only does this environment give protection from the current, but it is also a superb hiding place from fish-eating predators. This is also the





Above: Trout fry, three months after hatching. They have every feature of the adult trout, but are only about 1.5cm (½in) long.

Below: A male three-spined stickleback displays over his nest site.

living space of the young pike in its first year, too small at 5cm (2in) or so to be a fish eater.

The minnow and bleak are stronger swimmers than the stickleback, and are therefore better able to live in open water. The minnow lives close to the river bed or in mid-water, and the bleak lives near the surface. Minnows feed on bottom-dwelling crustaceans and insect larvae; bleak feed on planktonic crustaceans, surface-living and wind-blown insects, and spiders which fall into the water. Thus, although both are found close together in the same river, they do not compete for food to any extent. However, living in open water they are vulnerable to predators, and both adopt the same strategy to avoid being eaten: they are fast-swimming and form schools.

The minute fry of such fishes as roach, rudd, dace and minnows are also schooling fish but, lacking the speed of the adults because of their small size, they adopt a strategy of living close to the shore, either near cover or in very shallow water. Although the choice of shallow water makes them conspicuous and more vulnerable to birds like kingfishers, it actually offers protection from the many more underwater predators–pike, perch, trout and chub, and such birds as grebes.

Slow water specialists Small fry in still waters or very slowly flowing streams also include the ruffe. A relative of the perch, this species is at its most abundant in the eastern counties of England. It has the spiny dorsal fin of its cousin, but is a speckled pale brown in colour. It has a series of cavities on the underside of its head which may be sensory in function–evidence for this is the fact that it lives close to the bottom and would clearly benefit from such organs. The ruffe feeds extensively on bloodworms, the larvae of non-biting midges which are abundant in the rich bottom-mud of slow-flowing rivers.

Similar habitats are adopted by the nine-spined stickleback, which lives in still waters–often those that are very muddy and choked with vegetation and dead leaves. Occasionally this fish is abundant in ditches with only inches of water above the mass of dead leaves, rotting plants and mud–a most unpromising habitat for any small fish. One might expect such habitats frequently to be very poor in dissolved oxygen, so it is no surprise to learn that in experiments this stickleback has been proved to need much less oxygen in the water than its relative, the three-spined stickleback.

The two species of stickleback avoid competing with one another for living space not only by their choice of habitat but also because the three-spined stickleback builds its nest on the bottom of the pond or stream, while the nine-spined stickleback makes a nest among the vegetation a few inches off the bottom.

The gudgeon, one of the larger mini-species in our fresh waters, lives in both lakes and rivers, but in the rivers it is more or less confined to the slow-flowing lowland reaches. As its flattened belly and short barbel at each corner of the mouth suggest, it feeds on bottom-living insect larvae, crustaceans and molluscs, and forms small schools which, when feeding, work along the bottom.